PUMPING TEST RESULTS and REMEDIAL DESIGN GROUNDWATER MODELING REPORT

AREA E – BUILDING 11 TANK EXCAVATION AREA

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ATLANTIC CITY INTERNATIONAL AIRPORT
NEW JERSEY

Prepared for
Federal Aviation Administration
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Atlantic City International Airport, New Jersey

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TRC Project No. 162662-000140-000100

July 2010

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1.0 INTRODUCTION

A pumping test and groundwater modeling were conducted for Area E, the Building 11 Tank Excavation Area, located on property leased to the New Jersey Air National Guard's 177th Fighter Wing by the Federal Aviation Administration (FAA) at the William J. Hughes Technical Center (Technical Center). The location of Area E on the Technical Center property is presented on Figure 1. Area E-specific site features are shown on Figure 2. The objective of the pumping test and modeling effort for Area E is to assist with the design of a remediation system to capture contaminants in the Shallow Aquifer.

Area E was the site of a former heating plant and several wooden Atlantic City Naval Air Station (ACNAS) structures, presumed to be barracks. A 20,000-gallon underground storage tank (UST) that stored No. 6 fuel oil for heating operations was removed in 1985, and some fuel was found to have leaked from the tank, impacting subsurface soils and groundwater. The barracks were removed about the same time as the heating plant. Remedial investigations at Area E determined that soils and groundwater are impacted with volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, and/or metals.

A pumping test was performed in April, 2010. Installation of the observation wells for the test was completed in early April, and background monitoring began April 13. A step-drawdown test was conducted April 14, and a 72-hour sustainable rate test was performed April 16 – 19, followed by a 24 hour period of water level recovery monitoring. Analysis of the pumping test data was performed late April and early May, 2010. The groundwater modeling was completed in May. This report summarizes the design, preparation, and field activities for the pumping test, the results of analysis of the pumping test data, and the modeling and the conclusions of the modeling pertaining to the well field design for capture of the contaminants.

1.1 Area E Background Information

Groundwater contamination in Area E consists of VOCs, SVOCs, pesticides, and metals. Free product occurs in monitoring well E-MW3S. Details of the locations and concentrations of the contaminants are described elsewhere (TRC, 2003; TRC, 2010b). The general spatial distribution of Area E groundwater contamination is shown on Figure 3.

The groundwater contamination in Area E is restricted to the Shallow Aquifer. The Shallow Aquifer is unconfined. Recent water level data (September through December 2009; Table 1) indicate the water table occurs at depths ranging from approximately 11 feet below ground surface (ft bgs) (E-MW6S) to 19.5 ft bgs (E-MW9S). Historic data (1987 – 1989; Table 2) indicate water level variations of 5 to 6 feet. The vertical extent of contamination is restricted to the upper part of the Shallow Aquifer, where the shallow monitoring wells are screened (TRC, 2010b). The potentiometry for December 2009 is shown on Figure 4. Groundwater flows from northwest to southeast across Area E.

A total of 10 monitoring wells are present at Area E (Figure 3, Table 3). Nine of these monitoring wells are installed across the water table at screen depths ranging from 10 to 34 ft bgs. Monitoring well E-MW7D is screened at depths of 50 to 55 ft bgs. Three observation wells (Figure 3) were installed in the same depth interval as monitoring well E-MW2S (Table 3) for recording water levels during the pumping test. Monitoring wells E-MW1S, E-MW2S, E-MW3S, E-MW4S, and E-MW5S were installed in the 1980s. Monitoring wells E-MW6S, E-MW7S, E-MW7D, E-MW8S, and E-MW9S were installed October, 2009. Appendix A contains Area E well construction logs and descriptions of lithology.

2.0 CONCEPTUAL MODEL

2.1 Technical Center Geology

The sedimentary strata underlying the Technical Center include Quaternary deposits and the Upper Cohansey Sand. The Quaternary deposits are Recent sediments consisting of sand, gravel, and clay ranging in thickness from 30 to 50 feet in the vicinity of the Atlantic City Municipal Utilities Authority (ACMUA) well field (Weston, 1984). Sand and gravel are the dominant sediments. Clay beds as thick as 10 feet were encountered during the drilling for the Weston study, but the clay is laterally discontinuous.

The Cohansey Sand, underlying the Quaternary deposits, is part of an Atlantic Coastal Plain, seaward-dipping wedge of unconsolidated sediments that range in age from Cretaceous to Holocene (Rooney, 1971). These sediments were deposited in beach and shelf environments. Interbedded fine-grained sediments are transgressive marine deposits that formed during major incursions of the sea.

The Tertiary-aged Cohansey Sand is generally a deltaic deposit, but it contains sediments from nearshore marine, fluvial, estuarine, lagoonal, and beach environments (Rhodehamel, 1973). The Cohansey Sand is composed of fine to coarse quartz sand, lenses of clay, and lenses of gravel (Hardt and Hilton, 1969). Grain size varies both vertically and laterally, which is consistent with deposition within a coastal environment.

The Cohansey Sand is locally subdivided into an Intermediate Cohansey Aquifer (Intermediate Aquifer) and a Deep Cohansey Aquifer (Deep Aquifer). The Middle Cohansey Clay, 35 to 40 feet thick and separating the two aquifers, occurs throughout the subsurface beneath the Technical Center and surrounding area (TRC, 1989).

The Upper Cohansey Clay locally separates the Cohansey Sand from the shallow Quaternary deposits (Shallow Aquifer) in the vicinity of the ACMUA well field and Area 20A. The Upper Cohansey Clay pinches out between the Upper Atlantic City Reservoir and Area E. The Upper Cohansey Clay is also absent in the vicinity of the Area B injection wells. On the western half of the site, therefore, the Shallow and Intermediate Aquifers are contiguous. Lenses of silt and clay occur within the Shallow Aquifer.

2.2 Area E Geology

The Quaternary deposits in the vicinity of Area E consist primarily of fine to medium sand and fine to coarse sand. Silt and clay are minor components in a generally un-stratified sequence. There is no basis for subdividing the unit.

Given the absence of the Upper Cohansey Clay in Area E, the contact between the Quaternary deposits and the underlying Cohansey Sand is assumed to be transitional, as seen in the vicinity of the Area B injection wells. The occurrence of gravel at 54 feet in the borehole for E-MW7D is assumed to be within the Intermediate Aquifer. Furthermore, assuming the reddish-brown sand at the 50-foot depth that was described in this borehole (Appendix A) represents oxidation associated with sub-aerial exposure, the top of the Cohansey Sand is assigned this depth. On this basis and the depths to groundwater in E-MW7S ranging from 14 to 16 feet (Table 1), the Shallow Aquifer is assumed to have a saturated thickness of approximately 35 feet for the pumping test analyses and groundwater modeling.

2.3 Hydrology and Hydrogeology

The 30-year (1971-2000) average annual precipitation at the Atlantic City International Airport is 40.59 inches (http://climate.rutgers.edu/stateclim_v1/norms/daily/atlanticcityap.html). Model calibration for a groundwater classification exception area (CEA) delineation performed by TRC at the Technical Center (the Area 29 CEA delineation) indicated that groundwater is recharged at a rate of 21.6 percent of the average annual precipitation rate (TRC, 2009). This recharge rate was applied for calibration of the site-wide (Technical Center) comprehensive groundwater model used in the CEA delineation for Area B injection, Area 41 injection, and the recharge bed (TRC, 2010a).

The Shallow Aquifer is unconfined. The Intermediate Aquifer is confined in the vicinity of the Upper Atlantic City Reservoir and Area 20A, where shallow groundwater levels and flow are controlled by surface water. The Intermediate Aquifer is unconfined west of the Upper Atlantic City Reservoir. Aquifer testing data (TRC, 2010a) indicate the hydraulic conductivity of the Intermediate Aquifer is much higher than the Shallow Aquifer. Partly due to this difference in hydraulic conductivity, the potentiometry of the Intermediate Aquifer is distinct from the Shallow Aquifer, even in areas where the Intermediate Aquifer is unconfined.

The Deep Aquifer is confined. The ACMUA wells are completed in the Deep Aquifer. Results of analyses of pumping test data for the ACMUA well field indicated that the Middle

Cohansey Clay is a leaky aquitard (Weston, 1984). Vertical gradients are currently downward from the shallow unconfined groundwater into the Deep Aquifer. Pumping-induced head losses in the Deep Aquifer propagate through the Middle Cohansey Clay, influencing groundwater flow in the Intermediate Aquifer.

Discharge of groundwater to the South Branch Absecon Creek (SBAC) is a significant influence on the northwest to southeast direction of groundwater flow in the Shallow Aquifer at Area E. Short term, seasonal, and longer term water level variations in this water table aquifer are a direct result of the amount and frequency of precipitation.

Slug tests performed in the 1980s in monitoring wells E-MW1S and E-MW2S indicated hydraulic conductivity values of 1.7×10^{-3} centimeter per second (cm/sec) and 1.2×10^{-3} cm/sec for the upper part of the Shallow Aquifer in Area E (TRC, 1989). Without a basis for vertical subdivision of the Quaternary sediments in Area E, the hydraulic conductivity is assumed to be similar throughout the vertical extent of the Shallow Aquifer. Furthermore, logs of boreholes throughout Area E (Appendix A) provide no strong basis for significant and large scale lateral variations in hydraulic conductivity.

3.0 PUMPING TEST

3.1 Design

3.1.1 Selection of Monitoring Well for Pumping Test

Prior to the selection of monitoring well E-MW2S for use as the pumping well during the Area E pumping test, two monitoring wells were considered for this purpose, E-MW2S and E-MW8S. On March 25, 2010, TRC personnel performed a preliminary, small-scale step-drawdown test on these two monitoring wells. The purpose of the preliminary step-drawdown test was to determine which of these two wells could produce the highest sustainable yield and therefore be the optimal well to use during the full-scale pumping tests. To this end, monitoring well E-MW2S was pumped using a Grundfos Redi-Flo2 submersible pump at rates of 1.1 gallons per minute (gpm), 2.1 gpm, 3.3 gpm, and 5.7 gpm. The duration of pumping for each pumping rate was 10 minutes, 5 minutes, 10 minutes, and 10 minutes, respectively. Water levels (depth-to-water from top-of-casing) were measured in both monitoring wells using an electronic water level indicator (EWLI). For monitoring well E-MW2S, the water levels for each of the pumping rates described above stabilized within 30 seconds for the first three pumping rates, and stabilized after three minutes when pumped at 5.7 gpm. Monitoring well E-MW8S was also evaluated by pumping with a Grundfos Redi-Flo2 submersible pump. E-MW8S was pumped at rates of 1.2 gpm, 2 gpm, 4 gpm, 5.7 gpm, and 8.3 gpm. The duration of each pumping rate was 10 minutes, 15 seconds, 10 minutes, 2.5 minutes, and 10 minutes, respectively. For monitoring well E-MW8S, the water levels stabilized for each of the first four pumping rates at times of 45 seconds, 15 seconds, 45 seconds, and 45 seconds. The water level did not stabilize in E-MW8S for the 8.3 gpm rate.

Based on the roughly similar results observed during the preliminary step-drawdown tests, and to a lesser extent, because of logistical considerations related to an on-going construction project in the vicinity of monitoring well E-MW8S, monitoring well E-MW2S was chosen as the full-scale pumping test well.

Analytical solutions are utilized to determine aquifer properties from pumping test data. These solutions rely upon simplifying assumptions that include a horizontal potentiometric surface prior to pumping. A hydraulic gradient through the test area produces a non-concentric cone of depression, in which drawdown at a given distance upgradient is unequal to drawdown downgradient. In order to obtain the best estimates of aquifer properties based upon theoretical drawdown in the analytical solutions, the planned locations of the observation wells were cross-gradient of the pumping well. Analysis of aquifer properties was planned only for data from these observation wells and the pumping well.

Another consideration in pumping test design is the effect of partial penetration of the pumping well. Flow toward a partially penetrating well will have vertical flow components, affecting the potential field caused by drawdown. Many of the analytical solutions for pumping test data do not account for the effects of partial penetration. The solutions that include partial penetration effects incorporate the anisotropy in hydraulic conductivity, i.e., the ratio of vertical/horizontal hydraulic conductivity (Kv/Kh), adding complexity to the solution and potentially non-uniqueness and uncertainty to the result. The test design included locating two of the observation wells at sufficient distances to minimize partial penetration effects. Also, the distances of the near and far observation wells were planned to utilize the different storage responses of a water table aquifer as a function of pumping time and distance from the pumping well in the analysis of the drawdown data (Fetter, 1994).

Planning included performing Theis drawdown calculations prior to installing the observation wells to evaluate the potential drawdown as a function of the pumping rate, time, distance from the pumping well, hydraulic conductivity, anisotropy, saturated thickness, and aquifer storage. Ranges of parameter values were used in these calculations based upon existing data on the nature of the Shallow Aquifer in Area E. The results of these calculations provided an indication of the potential sustainable pumping rate for the testing and support for the choice of observation well distances from the pumping well.

3.2 Preparations

3.2.1 Observation Well Installation

Three observation wells were installed in the vicinity of E-MW2S on April 1, 2010 to generate additional data points for observing water level drawdown during the pumping test. E-OW1S was installed approximately 4.3 feet to the west of monitoring well E-MW2S. E-OW2S was installed approximately 110 feet cross-gradient and to the west-southwest of E-MW2S. E-OW3S was installed approximately 110 feet cross-gradient and to the east-northeast of E-MW2S. The groundwater contours used to determine the cross-gradient orientation were generated from water levels obtained from the Area E monitoring wells on December 11, 2009. Figure 3 shows the locations of the pumping well, the three observation wells installed for the aquifer testing, and the other wells that were monitored for radius of influence and background water levels. The observation wells were installed using hollow stem auger drilling techniques by East Coast Drilling, Inc., working under the supervision and direction of a TRC geologist. Soil sampling and stratigraphic logging were not part of the scope of work during the observation well installations. However, based on visual observation of the drill cuttings by the field geologist, the aquifer materials that the observation wells were screened to (silty sands) appeared similar to aquifer materials observed during the Pre-Design Activities and Sampling of September – November 2009 (TRC, 2010b). The observation wells were installed so that the screened interval elevations matched as closely as possible to the screened interval elevation of monitoring well E-MW2S (approximate elevations of 27.5 feet to 47.5 feet, North American Vertical Datum 1988 (NAVD88)). The observation wells were constructed of 20-foot long, 2-inch diameter polyvinyl-chloride (PVC), 0.010-inch slot screen and 2-inch diameter PVC riser pipe. Filter pack sand consisted of #0-sized silica sand extending from the bottom of the well screen to two feet above the well screen, with a #00-sized "choke" sand to two feet above the top of the #0-sized sand, and bentonite cement grout from the top of the "choke" sand to the ground surface. The observation wells were completed at the ground surface with locking stick-up steel protectors.

Following installation, the observation wells were developed to remove silt from the filter pack and to facilitate proper communication between the Shallow Aquifer and the well screen. Observation well E-OW1S was developed using a Grundfos Redi-Flo2 submersible pump that was lowered into the saturated portion of the well screen and used to surge and pump the well screen simultaneously. Due to very high silt content, observation wells E-OW2S and E-OW3S were developed using a Waterra Hydralift pump initially, then later by using the Redi-Flo2 once the silt content diminished.

3.2.2 Pressure Transducer Setup

Eight In-Situ, Inc. Level Troll® Model 700 vented data-logging pressure transducers were deployed by TRC personnel into five monitoring wells and three observation wells at Area E prior to initiation of the pumping tests. The wells in which the transducers were installed were monitoring wells E-MW1S, E-MW2S, E-MW5S, E-MW6S, and E-MW8S and observation wells E-OW1S, E-OW2S, and E-OW3S. Following deployment, the transducers were programmed using a RuggedReader® handheld computer to calculate water levels from the water pressures measured by the transducers. Initial water levels used in the transducer water level calculations were measured from each well's top of casing using an EWLI to the nearest 0.01 foot. All pressure transducers began measurements on April 13, 2010 and were turned off on April 20, 2010. Furthermore, the pumping well and the three observation wells were linked by an In-Situ, Inc. Virtual Hermit® hub which permitted real-time display of water level data on a laptop computer linked to the hub during the different phases of the pumping test (e.g. background measurement period, step-drawdown test, etc.).

3.2.3 Pumping Well, Transfer Tank, and Fractionalization Tank Setup

A Grundfos Redi-Flo3 submersible pump was deployed into monitoring well E-MW2S and was used for the duration of the pumping test. A second Redi-Flo3 was procured and set-up with tubing and safety cord at the ground surface for rapid deployment if the first pump failed. The second Red-Flo3 pump was not needed. The down-well pump was deployed so that the center of the pump intake was three feet above the bottom of the well, approximately 30.75 feet from the top of the well casing. The pump and associated piping were plumbed by TRC personnel. All piping was either ¾-inch diameter polyethylene or ¾-inch diameter steel. A globe valve was fitted to the piping at the wellhead for discharge control. Downstream from the globe valve, a SeaMetrics MJT analogue pulse meter flow totalizer was installed that was plumbed in accordance with the manufacturer's recommendations with regards to the upstream and downstream distances to fittings. Downstream of the totalizer, a splitter was installed to allow for manual measurements (bucket tests) to check instantaneous flow rates. The other side of the splitter ran to a 600-gallon transfer tank. Lay-flat hose attached to a transfer pump placed in the bottom of the transfer tank then piped the water into one of two 21,000-gallon fractionalization tanks. The Redi-Flo3 pump, transfer tank pump, laptop computer for monitoring real-time water level data from the pressure transducers, and lighting units for night work were powered by 3000-watt gas-powered generators. Three generators were utilized on-site; two ran at all times and the third was held in reserve in case one of the two operating generators malfunctioned.

3.3 Test Performance and Observations

3.3.1 Background Water Level Measurements

Upon arrival at the site on April 13, 2010, TRC personnel began manual water level measurements using an EWLI in all of the Area E monitoring wells except for E-MW3S, and in all three observation wells (E-MW1S, E-MW2S, E-MW4S, E-MW5S, E-MW6S, E-MW7S, E-MW7D, E-MW8S, E-MW9S, E-OW1S, E-OW2S, and E-OW3S). No water levels were measured in monitoring well E-MW3S because of the presence of a layer of #6 fuel oil which floats on top of and within the well's water column. Following deployment of the pressure transducers as described in Section 3.2.2, water level measurements were also obtained on an automated basis from monitoring wells E-MW1S, E-MW2S, E-MW5S, E-MW6S, and E-MW8S, and from observation wells E-OW1S, E-OW2S, and E-OW3S. During the background water level measurement period, the pressure transducers recorded a water level measurement once every second in the "hubbed" wells (E-MW2S, E-OW1S, E-OW2S, and E-OW3S), and once every 15 minutes from the other transducer-equipped wells. Background water level measurements continued until the start of the step-drawdown test on April 14.

Precipitation data was also recorded for the period of the background water level measurements. Precipitation data came from the National Weather Service weather station at the Atlantic City International Airport, and was obtained from the internet at http://www.weather.gov/climate/index.php?wfo=phi. For the period of background water level measurements, (April 13 to April 14) 0.07 inches of precipitation were recorded at the weather station, with all of the precipitation occurring on April 13.

During the background water level measurement period, water levels in monitoring wells E-MW1S, E-MW2S, and E-MW6S fell after the beginning of water level measurements, with a slight rebound towards the end of the background monitoring period. The water levels in monitoring wells E-MW4S, E-MW7S, E-MW7D, E-MW8S, and E-MW9S and in observation wells E-OW1S, E-OW2S, and E-OW3S increased during the beginning of the background monitoring period, fell during the middle, then rebounded slightly at the end of the background monitoring period. The magnitude of the differences in water levels observed in all of the monitoring wells and observation wells during the background monitoring period was on the order of hundredths (0.01) of feet. One exception to note is for monitoring well E-MW5S; this well was pumped by TRC personnel upon arrival at the site on April 13 at a rate of 2 gpm in order to evacuate 3 well volumes and obtain a groundwater sample for the Area E Treatability Study. Approximately 86 gallons were pumped from E-MW5S during the late morning of April 13. Because of the pumping of E-MW5S, the water level in this well dropped by approximately 1.5 feet initially on April 13, then rebounded by approximately 0.75 feet between sample collection and just prior to the start of the Step-Drawdown test.

3.3.2 Step-Drawdown Test

The step-drawdown test was performed on April 14, 2010. The purpose of the step-drawdown test was to stress the aquifer at different pumping rates to determine the optimal pumping rate to use during the 72-hour sustainable rate test that would result in the calculation of aquifer parameters at Area E.

E-MW2S was pumped at rates of 4 gpm, 10 gpm, 7 gpm, and finally 8.5 gpm (in that order) during the step-drawdown test. The rates were checked at the wellhead using a calibrated 5-gallon bucket and by measuring the amount of time it took for the bucket to be filled to the 5-gallon mark. The amounts of time that the well was pumped at the aforementioned rates were approximately 28 minutes, 141 minutes, 60 minutes, and 75 minutes, respectively. With the exception of the 10 gpm rate, the water level achieved stability at each of the pumping rates.

Based on data from the Atlantic City International Airport National Weather Service weather station, there was no precipitation during the step-drawdown test.

During the step-drawdown test, the pressure transducers were programmed to record a water level every 0.5 second in the "hubbed" wells and every second in the "outer" wells (E-MW1S, E-MW5S, E-MW6S, and E-MW8S).

During the 4 gpm step, the water level in E-MW2S fell initially, and then stabilized. The overall change in water levels observed in E-MW2S during this initial step was 1.47 feet. The water level in E-OW1S fell initially, and then stabilized. The overall change in water levels observed in E-OW1S was 0.68 feet. The water level in E-OW2S changed only slightly during the 4 gpm step, with an overall difference of 0.03 feet. Similarly, the water level in E-OW3S had an overall change of 0.04 feet.

During the 10 gpm step, the water level in E-MW2S fell by approximately 7 feet, then nearly reached stabilization, but then became erratic. Based on the erratic water levels observed in E-MW2S toward the end of the 10 gpm step period, stability was not reached. The overall change in water levels observed in E-MW2S during this second step was 12.35 feet. The water level in E-OW1S fell slightly toward the beginning of the 10 gpm step, and then decreased in small increments with time. The overall change in water level observed in E-OW1S was 1.27 feet. The water level in E-OW2S changed by 0.06 feet and by 0.04 feet in E-OW3S during the 10 gpm step.

During the 7 gpm step, the water level in E-MW2S rebounded rapidly by approximately 9 feet, then decreased by about 1.5 feet, then rebounded slightly and achieved stability. The overall change in water levels observed in E-MW2S during the 7 gpm step was 9.19 feet. The water level in E-OW1S rebounded slightly then stabilized, with an overall change of 0.24 feet. The water levels in E-OW2S and E-OW3S changed only slightly during the 7 gpm step, with overall changes of 0.06 feet and 0.04 feet, respectively.

During the 8.5 gpm step, the water level in E-MW2S initially dropped by approximately 3 feet, and then stabilized briefly before dropping another foot. The water level in E-MW2S stabilized for the approximate second half of the 8.5 gpm step period. The overall change in water levels observed in E-MW2S during the 8.5 gpm step was 3.70 feet. The water level in E-OW1S decreased slightly, then stabilized. The overall change in water levels observed in E-OW1S was 0.23 feet. The water levels in E-OW2S and E-OW3S changed only slightly during the 8.5 gpm step, with overall changes of 0.03 feet and 0.01 feet, respectively.

For the "outer" wells that were transducer-equipped, changes in water levels ranged from 0.01 feet (E-MW6S) to 0.22 feet (E-MW8S) throughout the duration of the step-drawdown test.

3.3.3 72-Hour Sustainable Rate Test

Based on the results of the step-drawdown test, during which monitoring well E-MW2S exhibited relative stability at a pumping rate of 8.5 gpm, it was determined that a rate of 8.5 gpm would be used during the 72-hour sustainable rate test. Following monitored recovery of the pumping well after the step-drawdown test, a determination was made to start the 72-hour sustainable rate test on April 16, instead of the day immediately following the step-drawdown test. This was because of residual drawdown observed in E-MW2S on April 15 of approximately 0.4 feet.

No precipitation was recorded at the Atlantic City International Airport National Weather Service weather station on April 15.

Prior to starting the 72-hour sustainable rate test, the transducers in the "hubbed" wells were programmed to collect water levels on a logarithmic scale, while the transducers in the "outer" wells were programmed to collect a water level once every minute.

The 72-hour sustainable rate test was started at 10:32 A.M. on April 16, and continued uninterrupted until 11:11 A.M. on April 19. Based on data obtained from the Atlantic City International Airport National Weather Service weather station, 0.02 inches of precipitation was recorded on April 16 from midnight to 12 noon, and 0.12 inches of precipitation was recorded on April 16 from 12 noon to 11:59 P.M. No precipitation was recorded from April 17 through the end of the 72-hour sustainable rate test on April 19. The total precipitation for the duration of the 72-hour sustainable rate test was 0.14 inches.

As described above, the 72-hour sustainable rate test was started with a discharge rate of 8.5 gpm. A tolerance of plus or minus 10% of the overall discharge rate was utilized during the test. The flow was confirmed using both the inline totalizer and the manual method (bucket test). However, due to water level instability and because the water level was drawing down very close to the transducer in E-MW2S, the discharge was reduced to 8 gpm at approximately 9:00 P.M. on April 16. Unstable water levels caused another reduction in discharge rate, this time to 7.5 gpm, at approximately 1:30 P.M. on April 17. 7.5 gpm was used as the target discharge rate from 1:30 P.M., April 17 to the conclusion of the test on April 19.

Initially during the 72-hour sustainable rate test, the water level in E-MW2S fell from 14.58 feet to 26.84 feet after approximately five hours of pumping. The water level then fluctuated, ranging from approximately 24 feet to 28 feet for the duration of the test. From the start of the 72-hour sustainable rate test to approximately Hour 11, the water level in E-OW1S fell from 17.32 feet to 19.36 feet. Except for some minor fluctuations early in the pumping test, the water level in E-OW1S continued to fall in small increments until the end of the test on April 19. The lowest water level observed in E-OW1S was 19.77 feet, measured at 7:13 A.M. on April 19. During the course of the 72-hour sustainable rate test, the water level in E-OW2S fluctuated between 17.48 feet to 17.93 feet, with a general decreasing trend. With the exception of a brief rebound in the water level at the onset of the 72-hour sustainable rate test of approximately 0.05 feet, the water level in E-OW3S steadily fell, ranging from 17.12 feet to 17.45 feet.

Water levels in the "outer" wells equipped with transducers exhibited similar results to the two observation wells farthest from the pumping well (E-OW2S and E-OW3S). In E-

MW1S, the water level fluctuated during the 72-hour sustainable rate test, with a general decreasing trend. The water level ranged from 14.17 feet to 14.47 feet. In E-MW5S, the water level fluctuated, also with a decreasing trend. The water level ranged from 17.19 feet to 17.56 feet. In E-MW6S, the water level exhibited a decreasing trend throughout the duration of the 72-hour sustainable rate test, ranging from 11.44 feet to 11.68 feet. The water level in E-MW8S fluctuated, with a decreasing trend. The water level ranged from 19.02 feet to 19.39 feet.

3.3.4 Recovery Observations

Following cessation of the 72-hour sustainable rate test (i.e., shutdown of the pump in E-MW2S), water level readings continued to be collected both manually and with the pressure transducers in order to monitor recovery of the aquifer. Prior to the start of the recovery period, the transducers in the "hubbed" wells were programmed to collect water levels on a logarithmic scale, while the transducers in the "outer" wells were programmed to collect a water level once every minute.

The objective was to monitor the aquifer recovery until the water levels in all of the wells had rebounded to 90% of their static values just prior to the start of the 72-hour sustainable rate test.

Based on data obtained from the Atlantic City International Airport National Weather Service weather station, no precipitation was recorded during the recovery monitoring period (April 19 and April 20).

Within the group of "hubbed" wells, E-MW2S achieved 90% recovery at 11:14 A.M. on April 19. E-OW1S, E-OW2S and E-OW3S did not rebound to within 90% of the pre-72-hour sustainable rate test water level during the recovery monitoring period, which lasted from 11:11 A.M. April 19 to 11:23 A.M. on April 20. None of the "outer" wells equipped with transducers (E-MW1S, E-MW5S, E-MW6S, and E-MW8S) rebounded to within 90% of their respective pre-72-hour sustainable rate test water levels during the recovery monitoring period.

3.4 Data Reduction

Manipulation of data from the step-drawdown test was limited to calculating cumulative elapsed time for all the steps (rates) combined and plotting the elapsed time versus depth to water for analysis (Appendix B). The graphs were annotated with notes about times of rate changes.

Data reduction for the 72-hour sustainable rate test included subtraction of the background water level changes recorded in E-MW6S from the drawdown data for each of the observation wells (E-OW1S, E-OW2S, E-OW3S), including the pumping well (E-MW2S). Depth to water in E-MW6S versus time was plotted, and a least-squares trendline was fitted to the data (Appendix C). These data indicate a strongly linear decrease in aquifer water levels of about 0.33 feet during the pumping test and the period of recorded recovery. The equation of the trendline was used for calculating the change in water level per unit time for correction of the drawdown data during pumping and recovery.

A record of water levels in E-MW6S prior to the step-drawdown test confirms that water levels in the aquifer were decreasing naturally (Appendix C). These data indicate a very similar trend of background water level changes (i.e., the slope of the trendline is very similar), supporting the applied correction to the pumping drawdown and recovery data. Note that the depth to water of about 11.45 feet at the beginning of the 72-hour sustainable rate test is less than the depth to water of about 11.5 feet at the end of the period prior to the step-drawdown test. This inconsistency is artificial, due to a difference in the reference levels of the troll and, therefore, does not indicate water level recovery since the completion of the step-drawdown test.

Appendix D has plots of depth to water versus time and background water level corrected drawdown versus time for each of the observation wells and the pumping well. These plots include the instantaneous rates of extraction from E-MW2S as measured by bucket tests. Elapsed time since pumping began was calculated for the pumping and recovery periods.

The background water level correction was also applied to the depths to water in the other wells monitored for radius of influence (E-MW1S, E-MW5S, E-MW8S). Appendix E has plots of the corrected and uncorrected water levels for these wells.

3.5 Data Analysis

3.5.1 Step-Drawdown Test

Analysis of the step-drawdown test data suggested a rate of 8.5 gpm would be sustainable for the 72-hour pumping test based on stable water levels in the pumping well (E-MW2S) and the observation wells at the conclusion of step-testing with this rate (Appendix B). Using the drawdown observed in E-OW1S and E-OW2S, a calibration of the step-test data was performed with the Theis drawdown algorithm assuming a saturated thickness of 35 feet, a specific yield of 0.20, and Kv/Kh = 0.1 (Appendix F). This calibration suggests the aquifer has a hydraulic conductivity of approximately 4×10^{-3} cm/sec.

3.5.2 72-Hour Sustainable Rate Test

Inspection of the graphs of depth to water versus time for the observation wells and the other wells monitored for radius of influence revealed a cyclic pattern of interference (Appendices D and E), interpreted to be the effects of the intermittent usage of the nearby FAA potable wells completed in the Deep Aquifer. The effects on shallow water levels are temporary and reversible, which is attributed to the elastic response of the confined Deep Aquifer. However, the interference is so great relative to the corrected drawdown for E-OW2S and E-OW3S that it renders the data unusable (low signal/noise) to analyze for aquifer parameters. Nevertheless, the corrected data indicate that pumping influences were recorded in these two observation wells. The effects of pumping and recovery are also evident in the corrected depths to water for E-MW1S. The graphs of corrected depths to water for E-MW5S and E-MW8S suggest the data from these wells are slightly overcorrected (not showing a trend in drawdown), but the corrected data also show a general trend of recovery after the pump was shut off, indicating there was a pumping influence at these wells.

The pumping rate was evaluated with data from a flow totalizer and bucket tests. A pumping rate of 8.5 gpm was unsustainable during the 72-hour sustainable rate test. Drawdown approached the pump intake repeatedly, requiring downward adjustments to the flow rate (Figure 5). Both types of rate data show that a sustainable rate was achieved after about 50 hours of pumping. However, the flow totalizer rate deviates with time increasingly and systematically from the bucket test rate. Given the initial correspondence between the two rates, the flow totalizer became increasingly erroneous with time. The bucket test rates were used for analysis of the aquifer test data. These test data indicate a rate of 7 gpm is sustainable.

The software used to analyze the aquifer test data is AQTESOLV Pro Version 4.5 (HydroSOLVE.Inc., 1996-2007). This tool is used to fit theoretical curves for analytical solutions to the drawdown and recovery data, providing estimates of the hydraulic conductivity, storage, and vertical to horizontal ratio of hydraulic conductivity (anisotropy). The time-variant pumping rate data were utilized in the analyses.

Table 4 shows the results of analysis of pumping and recovery data from the pumping well (E-MW2S) and E-OW1S. Appendices G and H contain plots of the theoretical curves fitted to the data. The hydraulic conductivity values are consistent with the results of previous slug tests in monitoring wells E-MW1S and E-MW2S, which indicated hydraulic conductivity values of 1.7 x 10^{-3} cm/sec and 1.2 x 10^{-3} cm/sec, respectively. The value of hydraulic conductivity in bold type in Table 4, i.e., 4 x 10^{-3} cm/sec, is considered the best estimate based on use of the Neuman solution, which accounts for effects of partial penetration in an unconfined aquifer. This value is consistent with the value estimated from the step-drawdown test.

The storage parameters are not well constrained (Table 4), possibly due to pumping rate variations, aquifer heterogeneity, local semi-confined behavior due to local stratification, and interference from the FAA potable wells. There is no delayed gravity drainage response visible in the data. These data, however, are not important for design modeling of the remediation system or for long-term operation of the system.

The observation well data suggest there are lateral variations in hydraulic conductivity. The aquifer response in E-OW2S is approximately twice the response in E-OW3S (Appendix D), although each well is 110 feet from the pumping well. Furthermore, the observation data for E-MW1S indicate a response to pumping. These data suggest the hydraulic conductivity may be lower toward E-OW3S. Figure 6 also suggests aquifer heterogeneity by the inability to match all three data sets with one solution. Distance-drawdown solutions are meaningless with these conditions. A complicating factor or alternate interpretation is based upon the Theis residual drawdown solution for the recovery data for the pumping well, which yields S/S' > 1 (Table 4), indicative of a recharge source or leakage. Without a clay aquitard beneath the Shallow Aquifer in this area, leakage from the Intermediate Aquifer is a possibility. The departure of the theoretical curve for recovery from the data at late time (Figure 7), i.e., more rapid recovery than expected, supports leakage. Apparently due to heterogeneity and local aquifer stratification, this effect was not recorded in E-OW1S (Figure 8), which did not recover completely by the end of the recording period. The interpretation of leakage suggests that high rates of pumping should be avoided to prevent coning up water from the Intermediate Aquifer.

4.0 GROUNDWATER MODELING

Groundwater modeling for Area E was conducted utilizing the site-wide (Technical Center) comprehensive, three-dimensional numerical groundwater flow model that was developed for delineating the groundwater CEA for Area B injection, Area 41 injection, and the recharge bed (TRC, 2010a). The referenced report provides a full description of the model, including the calibration. Minor modifications were made to the model for the Area E groundwater modeling. These modifications are described in the following section.

4.1 Modifications of Technical Center Groundwater Flow Model

The Technical Center Model domain was expanded to the west 1,400 feet (Figure 9). This modification provides sufficient distance between the simulated Area E extraction wells and the western model boundary to avoid potential undesirable boundary condition effects on the Area E simulations. Fourteen columns of uniform 100 feet by 100 feet cells (the original grid cell dimensions) were added to the finite-difference grid. The grid cell size was then locally reduced to 25 feet by 25 feet over Area E (Figure 10) to accommodate the close spacing of the monitoring wells and the simulated extraction wells for better resolution of simulated groundwater levels.

Additional drain nodes, simulating discharge of groundwater to the SBAC, were added to the western extension of the model domain. Also, the drainage ditch west of Tilton Road was simulated with drain nodes. Figure 11 shows the surface water and Shallow Aquifer boundary conditions. Drain bottom elevations correspond to the approximate bed elevations along the SBAC and the ditch. The Shallow Aquifer constant head nodes and Deep Aquifer general head nodes on the western boundary were also moved to the new model boundary, and the heads were adjusted to reproduce the simulated heads of the original model.

Model layers 1 and 2 represent the Shallow Aquifer in Area E. Extraction wells were simulated in Layer 1. The bottom of model layer 1 was set locally to an elevation of 25 feet amsl in Area E to correspond to the anticipated design depth of the bottom ends of the extraction well screens. The layer 2 bottom is 5 feet amsl, the same elevation as the original model. The average simulated saturated thickness of the Shallow Aquifer in Area E is about 37 feet.

A uniform hydraulic conductivity value of 11 ft/day (3.9×10^{-3} cm/sec) and Kv/Kh of 0.2 was assigned to the Shallow Aquifer in the vicinity of Area E (Layers 1 and 2). This value is consistent with the results of analysis of the pumping and recovery data from observation well E-OW1S (Table 4).

All simulations were conducted as steady-state. The average pumping rates of the ACMUA production wells for the 3rd quarter of 2009 were simulated (TRC, 2010a). These rates are the most recent available rates for these wells. Injection into the Intermediate Aquifer at Area B was simulated at a total rate of 100 gpm. The total rate of injection into the Intermediate Aquifer at Area 41 was simulated at 40 gpm. Discharge to the Shallow Aquifer at the recharge bed was simulated at 250 gpm. These values represent typical operational rates. Any deviations of the actual rates from these simulated rates have little, if any, effect on simulated water levels in Area E.

The other remediation systems are simulated as they were for the CEA simulations, as documented in the CEA report (TRC, 2010a). Specifically, remediation system extraction wells for Area B and Area 20A, and the injection wells at Area 20A were simulated at the same rates used in the calibration of the Technical Center Model. The ten Area D extraction wells that have been operating were simulated at their respective design rates for the total design rate of 69 gpm. Because the six Area 41 extraction wells have been inconsistently operated at insignificant rates, for simplicity, each well was simulated at 1.67 gpm for a total of 10 gpm, which was the maximum average total monthly rate recorded during initial testing of these wells.

4.2 Baseline Simulation

Baseline simulation results represent the model reproduction of current groundwater levels in Area E. Figures 12A (water table) and 12B (model layer 3, E-MW7D completion depth) show the simulated water levels in Area E without remediation extraction. The values beside the monitoring wells represent the differences (errors) between measured water levels from November 2009 (Table 1) and simulated water levels. The November water levels are a complete set for Area E that is closest in time to 3rd Quarter 2009, for which ACMUA well rates are available and simulated in the model.

The errors in simulated water levels are about 2 feet or less (both higher and lower than measured). Improvement of the model match to measured values with variable hydraulic conductivity was not an objective for engineering design modeling. Furthermore, the irregularity of the potentiometry is not understood. The lithologic data do not suggest significant spatial differences in hydraulic conductivity, and the differences in water levels between sets of measurements (Table 1) are variable among the monitoring wells. It is noteworthy that the errors in simulated water levels are much less than the 5 to 6 feet of variation in historic water levels in Area E.

4.3 Remediation Well Field Design

The objective of the modeling effort for Area E is to assist with the design of a remediation system to capture the contaminants in the Shallow Aquifer. The model was used iteratively to determine the optimal number of extraction wells and pumping rates to provide complete capture of the contaminated groundwater. Particle tracking was performed with starting locations of the particles at the perimeter of the area of contamination shown on Figure 3. Particles were conservatively placed outside the perimeter on the down-gradient (south and southeast) side of the area of delineated contamination (Figure 13).

The modeling indicates five wells, each pumping at 5 gpm, are sufficient for complete plume capture. The optimal locations of the extraction wells are shown on Figure 14. The design locations of the extraction wells take into consideration existing and planned infrastructure.

Figure 15 shows the pumping cones of depression for the five well, 5 gpm design well field. Figure 16 shows the particle tracks demonstrating capture. The design rates of 5 gpm are based upon the drawdown that is required to capture the contaminants. The rates are less than the single well sustainable rate of approximately 7 gpm that was determined from the pumping test.

4.4 Sensitivity Simulations

Simulated capture was evaluated under potential conditions of higher and lower hydraulic conductivity than the model value used for the well field design. These scenarios use a uniform hydraulic conductivity to address the potential for local (extraction well location) differences in hydraulic conductivity, different from the pumping test result. Capture was also evaluated for higher and lower recharge rates than used for the baseline and design simulations.

Figure 17 shows the loss of capture with half an order-of-magnitude (5X) greater hydraulic conductivity with the wells pumping at 5 gpm. Under these conditions, 12 gpm may be required locally for capture (Figure 18). Under conditions of half an order-of-magnitude lower hydraulic conductivity, wells would pump at a lower rate, but capture can be achieved at 2 gpm (Figure 19), but potentially not at a lower rate (Figure 20).

A three-fold increase in the recharge rate could locally result in some loss of capture (Figure 21), suggesting periods of high water levels could require an increase in pumping rates. Figure 22 shows no loss of capture for a three-fold lower rate of infiltration. If drawdown increases due to water levels decreasing, the pumping rates may need to be decreased.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The results of analysis of the pumping test data indicate a best estimate of the hydraulic conductivity as 4×10^{-3} cm/sec and an anisotropy ratio (Kv/Kh) of 0.2. Similar parameter values were used in numerical modeling to design a well field for capture of contaminated groundwater in Area E. Observation data suggest there may be minor local variations in the aquifer properties.

Five extraction wells, each pumping at 5 gpm, will provide complete capture of the Area E contaminants. Testing of these wells is recommended to evaluate the potential for local variations in hydraulic conductivity that could impair the effectiveness of capture at a rate of 5 gpm. Water level monitoring data with associated water table contour maps should be used to evaluate the need for potential adjustments of pumping rates to ensure capture. High rates of pumping should be avoided to prevent coning up water from the underlying, unconfined Intermediate Aquifer.

6.0 REFERENCES

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Table 1

WATER LEVELS: September 15 - December 11, 2009

AREA E PUMPING TEST AND REMEDIAL DESIGN GROUNDWATER MODELING REPORT

FAA William J. Hughes Technical Center

WELL NUMBER	MEASURING POINT ELEVATION (FT MSL)[1]	GROUND ELEVATION (FT MSL)[1]	DEPTH TO WATER (FEET)[2]						DEPTH TO BOTTOM (FEET)[2,3]	WATER LEVEL ELEVATION (FT MSL)					
			9/15/2009	9/23/2009	10/6/2009	11/11/2009	12/9/2009	12/11/2009	9/15/2009	9/15/2009	9/23/2009	10/6/2009	11/11/2009	12/9/2009	12/11/2009
E-MW1S	62.20	59.78	18.84	18.97	18.92	17.67	N/M[4]	16.62	31.22	43.36	43.23	43.28	44.53	N/M	45.58
E-MW2S	61.66	60.21	18.54	19.07	18.88	17.44	N/M	16.55	33.40	43.12	42.59	42.78	44.22	N/M	45.11
E-MW3S	61.22	58.78	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/A	N/A	N/A	N/A	N/M	N/M
E-MW4S	59.27	57.45	15.47	19.52	19.24	18.65	N/M	17.19	32.25	43.80	39.75	40.03	40.62	N/M	42.08
E-MW5S	59.32	58.45	19.74	20.31	20.12	19.51	N/M	18.32	33.92	39.58	39.01	39.20	39.81	N/M	41.00
E-MW6S	59.77	56.96	---[5]	---	---	15.02	N/M	13.87	---	---	---	---	44.75	N/M	45.90
E-MW7D	58.19	55.74	---	---	---	19.19	17.98	18.08	---	---	---	---	39.00	40.21	40.11
E-MW7S	58.29	56.00	---	---	---	16.20	14.04	13.98	---	---	---	---	42.09	44.25	44.31
E-MW8S	60.86	59.13	---	---	---	21.17	N/M	20.02	---	---	---	---	39.69	N/M	40.84
E-MW9S	60.30	59.04	---	---	---	20.83	N/M	19.7	---	---	---	---	39.47	N/M	40.60

Notes: 1) Elevation in feet above mean sea level (Datum is North American Vertical Datum of 1988)

2) Depth as measured from top of inner well casing.

3) Depth to bottom was not measured during gauging events following the 9/15/09 work.

4) N/M = Not Measured; At E-MW3S, depth to product on 9/15/09 was 18.45 and on 9/23/09 was 18.50 feet below top of casing

5) --- = Monitoring well did not exist during this round of water level measurements

Table 2
HISTORIC AREA E WATER LEVELS
AREA E PUMPING TEST AND REMEDIAL DESIGN GROUNDWATER MODELING REPORT
FAA William J. Hughes Technical Center

WELL NUMBER	MEASURING POINT ELEVATION (FT MSL)[1]	DEPTH TO WATER (FEET)[2]							WATER LEVEL ELEVATION (FT MSL)						
		<--- 1987 --->			<--- 1988 --->			<---1989--->	<--- 1987 --->			<--- 1988 --->			<---1989--->
		24-Jun	15-Sep	19-Nov	19-Apr	8-Sep	1-Dec	16-Oct	24-Jun	15-Sep	19-Nov	19-Apr	8-Sep	1-Dec	16-Oct
E-MW1S	62.20	18.7	20.07	21.29	20.46	22.17	22.46	18.72	43.50	42.13	40.91	41.74	40.03	39.74	43.48
E-MW2S	61.66	18.19	19.71	20.98	20.28	21.93	22.23	13.46	43.47	41.95	40.68	41.38	39.73	39.43	48.20
E-MW3S	61.22	20.95	23.9	**	**	--	**	--	40.27	37.32	**	**	--	--	--
E-MW4S	59.27	--	--	--	--	--	21.86	17.8						37.41	41.47
E-MW5S	59.32	--	--	--	--	--	21.95	20						37.37	39.32

Notes: 1) Elevation in feet above mean sea level (Datum is North American Vertical Datum of 1988)

2) Depth as measured from top of inner well casing.

3) --- = Monitoring well did not exist during this round of water level measurements

Table 3

AREA E WELL CONSTRUCTION SPECIFICATIONS
AREA E PUMPING TEST AND REMEDIAL DESIGN GROUNDWATER MODELING REPORT
FAA William J. Hughes Technical Center

WELL NUMBER	ELEVATION TOP CASING[1] (ftmsl)	NORTHING[2]	EASTING[2]	GROUND ELEVATION[1] (ftmsl)	TOP OF SCREEN (ftbgs)	BOTTOM OF SCREEN (ftbgs)	ELEVATION TOP OF SCREEN[1] (ftmsl)	ELEVATION BOTTOM OF SCREEN[1] (ftmsl)	SCREEN LENGTH (ft)	SLOT SIZE (in)	WELL MATERIAL	WELL DIAMETER (in)
E-MW1S	62.20	222,543	468,203	59.78	10	30	49.78	29.78	20	0.015	PVC	4
E-MW2S	61.66	222,581	468,366	60.21	13	33	47.21	27.21	20	0.015	PVC	4
E-MW3S	61.22	222,485	468,349	58.78	10	30	48.78	28.78	20	0.015	PVC	4
E-MW4S	59.27	222,406	468,339	57.45	12	32	45.45	25.45	20	0.015	PVC	4
E-MW5S	59.32	222,484	468,406	58.45	14	34	44.45	24.45	20	0.015	PVC	4
E-MW6S	59.77	222,838	468,117	56.96	20	25	36.96	31.96	5	0.01	PVC	2
E-MW7S	58.29	222,348	468,538	56.00	20	25	36	31	5	0.01	PVC	2
E-MW7D	58.19	222,353	468,555	55.74	50	55	5.74	0.74	5	0.01	PVC	2
E-MW8S	60.86	222,559	468,514	59.13	27	32	32.13	27.13	5	0.01	PVC	2
E-MW9S	60.30	222,585	468,719	59.04	25	30	34.04	29.04	5	0.01	PVC	2
E-OW1S	63.50	222,583	468,363	60.24	13	33	47.24	27.24	20	0.01	PVC	2
E-OW2S	62.13	222,548	468,262	59.55	12	32	47.55	27.55	20	0.01	PVC	2
E-OW3S	64.65	222,636	468,463	61.90	14	34	47.90	27.90	20	0.01	PVC	2

Notes: 1) Elevation in feet above mean sea level (Datum is North American Vertical Datum of 1988)
2) New Jersey Plane Coordinate System (NAD 83)

TABLE 4

SUMMARY OF AREA E PUMPING TEST ANALYSES

AREA E PUMPING TEST AND REMEDIAL DESIGN GROUNDWATER MODELING REPORT

FAA William J. Hughes Technical Center

Well	Data	Solution	[2]T (cm^2/sec)	[3]K (cm/sec)	S	Sy	S/S'	Kv/Kx
E-MW-2S	Pumping	A	1.100	1.03E-03	-	0.18	-	-
		B	1.557	1.46E-03	-	0.24		0.2
	Recovery	C	8.533	8.00E-03	-	-	4.19	-
		[1]A	9.427	8.83E-03	-	-	-	-
E-OW-1S	Pumping	A	3.729	3.49E-03	-	0.15	-	-
		D	**4.302**	4.03E-03	-	0.36		0.2
	Recovery	C	3.800	3.56E-03	-	-	1	-
		[1]A	4.055	3.80E-03	-	0.1	-	-

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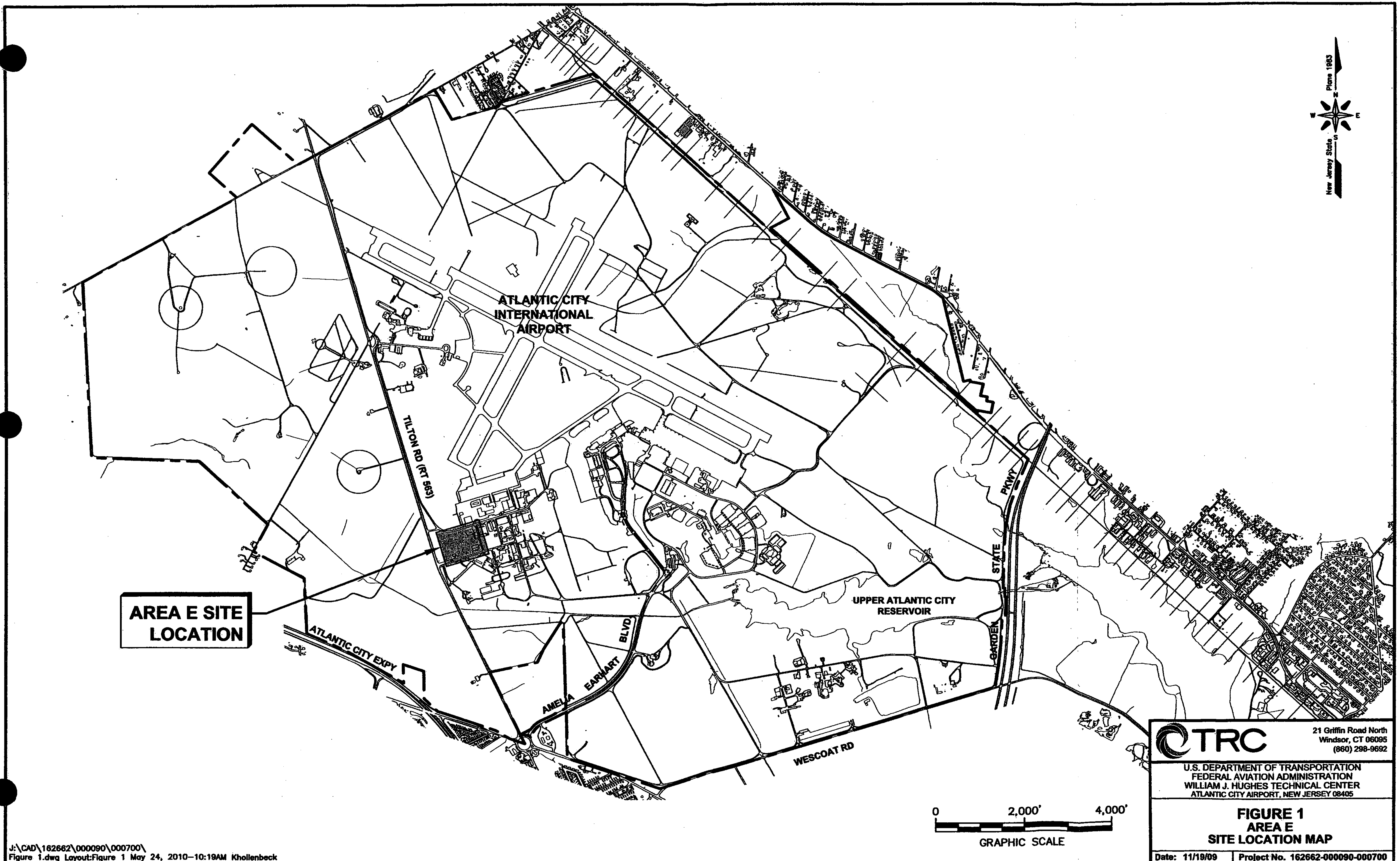
1 Agarwal (1980) showed that a simple transformation of the time data allows one to match type curves developed for drawdown analysis to recovery data. As implemented in AQTESOLV, pumping rates prior to recovery may be constant or variable with the Agarwal method.

2 Bold type is highest quality/reliability parameter value

3 Saturated thickness assumed 35 ft



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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
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FIGURE 1
AREA E
SITE LOCATION MAP

Date: 11/19/09 | Project No. 162662-000090-000700

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Figure 1.dwg Layout:Figure 1 May 24, 2010-10:19AM Khollenbeck

LEGEND

E-MW1S — MONITORING WELL LOCATION

E-OW1S — OBSERVATION WELL LOCATION

DEMOLISHED STRUCTURES

Orthophoto Source:
Publisher of Orthophotos is the NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS). Aerial photography of the entire State of New Jersey was captured during March–May, 2007. Two flight dates (4-30-07 and 5-3-07) with follow up flights on April 3rd, 10th and 15th of 2008.

SOURCE:
BASE MAP BY KUCERA INTERNATIONAL IS A FULL PHOTOGRAMMETRIC UPDATE OF AERIAL PHOTOGRAPHY ORIGINALLY TAKEN ON 03/19/01, PUBLISHED ON 11/07/2002 AND SUPPLIED BY THE FAA.
THE MAPPING COORDINATE SYSTEM IS NJ STATE PLANE NAD83 AND THE ELEVATION DATUM IS NAVD88.

0 60' 120'

GRAPHIC SCALE

TRC

21 Griffin Road North
Windsor, CT 06095
(860) 298-9692

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER
ATLANTIC CITY AIRPORT, NEW JERSEY 08405

FIGURE 2
AREA E
SITE FEATURES AND MONITORING WELL AND OBSERVATION WELL NETWORK

Date: 06/08/10 | Project No. 162662-000140-000100

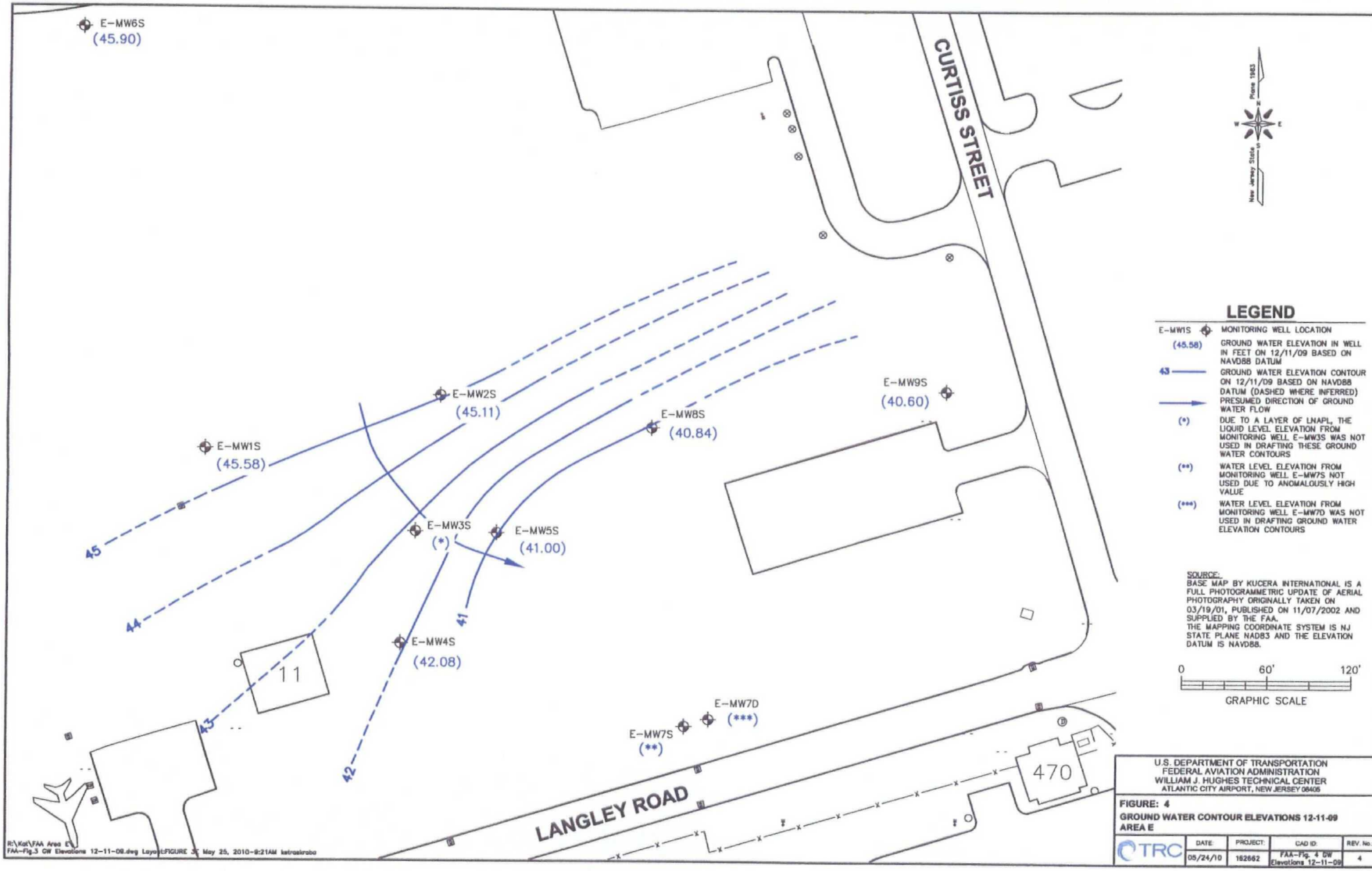
J:\CAD\162662\000140\000100\Pumping Test Report\Figure-1.dwg Layout:Figure 2 July 21, 2010-11:02AM Khallenbeck

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER
ATLANTIC CITY AIRPORT, NEW JERSEY 08405

FIGURE: 3

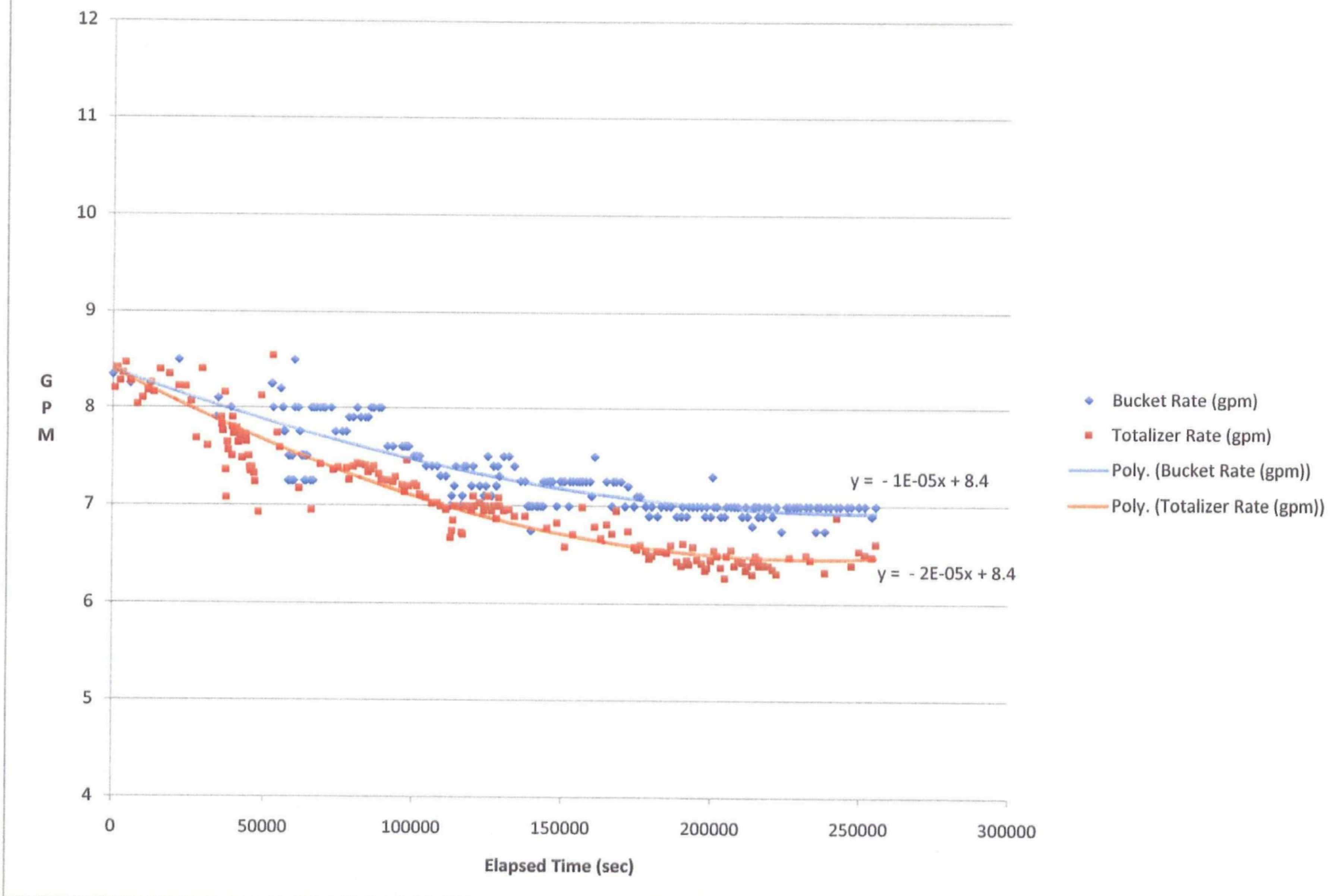
GENERAL SPATIAL DISTRIBUTION OF GROUND WATER CONTAMINANTS - AREA E

TRC	DATE:	PROJECT:	CAD ID:	REV. No.:
	05/24/10	162662	FAA-Fig. 3 Distrib of GW Contaminants	4



E-MW6S
(45.90)
CURTISS STREET
E-MW2S
(45.11)
E-MW1S
(45.58)
E-MW8S
(40.84)
E-MW9S
(40.60)
E-MW3S
(*)
E-MW5S
(41.00)
E-MW4S
(42.08)
E-MW7D
(***)
E-MW7S
(**)
45
44
43
42
41
11
470
LANGLEY ROAD
New Jersey State Plane 1983
LEGEND
E-MW1S MONITORING WELL LOCATION
(45.58) GROUND WATER ELEVATION IN WELL IN FEET ON 12/11/09 BASED ON NAVD88 DATUM
43 GROUND WATER ELEVATION CONTOUR ON 12/11/09 BASED ON NAVD88 DATUM (DASHED WHERE INFERRED)
PRESUMED DIRECTION OF GROUND WATER FLOW
(*) DUE TO A LAYER OF LNAPL, THE LIQUID LEVEL ELEVATION FROM MONITORING WELL E-MW3S WAS NOT USED IN DRAFTING THESE GROUND WATER CONTOURS
(**) WATER LEVEL ELEVATION FROM MONITORING WELL E-MW7S NOT USED DUE TO ANOMALOUSLY HIGH VALUE
(***) WATER LEVEL ELEVATION FROM MONITORING WELL E-MW7D WAS NOT USED IN DRAFTING GROUND WATER ELEVATION CONTOURS
SOURCE:
BASE MAP BY KUCERA INTERNATIONAL IS A FULL PHOTOGRAMMETRIC UPDATE OF AERIAL PHOTOGRAPHY ORIGINALLY TAKEN ON 03/19/01, PUBLISHED ON 11/07/2002 AND SUPPLIED BY THE FAA.
THE MAPPING COORDINATE SYSTEM IS NJ STATE PLANE NAD83 AND THE ELEVATION DATUM IS NAVD88.
0 60' 120'
GRAPHIC SCALE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER
ATLANTIC CITY AIRPORT, NEW JERSEY 08405
FIGURE: 4
GROUND WATER CONTOUR ELEVATIONS 12-11-09
AREA E
TRC
DATE: 05/24/10
PROJECT: 162662
CAD ID: FAA-Fig. 4 GW Elevations 12-11-09
REV. No.: 4

Figure 5: Flow Totalizer and Bucket Rates



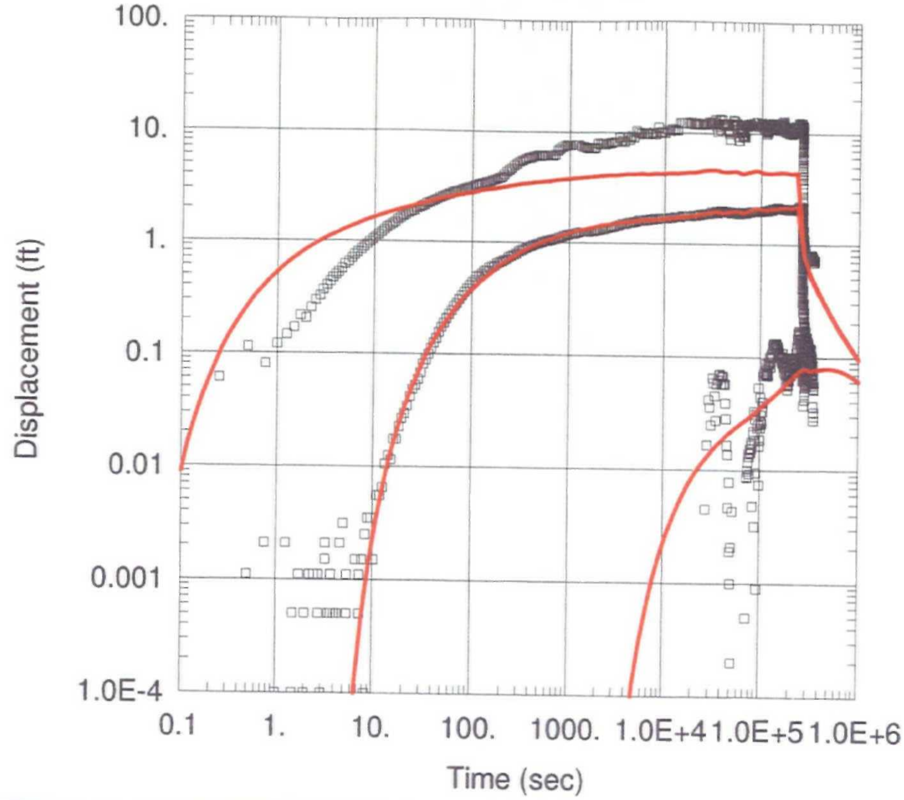


FIGURE 6: 72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\FAA\Area E\Report\Figures\Figure 6 All Wells.aqt
Date: 06/04/10 Time: 10:13:22

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ E-MW-2S	0	0
□ E-OW-1S	4.33	0
□ E-OW-2S	110	0

SOLUTION

Aquifer Model: Unconfined
Solution Method: Neuman

T = 4.302 cm^2/sec
Sy = 0.3552
S = 0.03733
Kz/Kr = 0.2

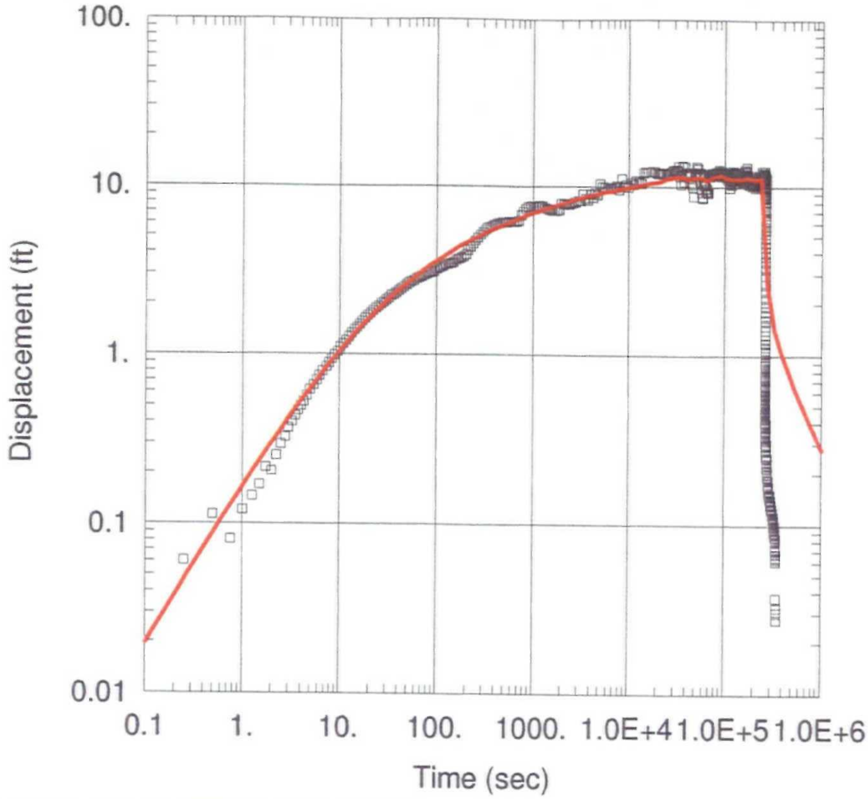


FIGURE 7: MOENCH SOLUTION FOR E-MW-2S

Data Set: C:\FAA\Area E\Report\Figures\Figure 7 Moench E-MW-2S.aqt
Date: 06/04/10 Time: 10:23:17

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ E-MW-2S	0	0

SOLUTION

Aquifer Model: Unconfined

T = 1.557 cm^2/sec
Sy = 0.2447
Sw = 0.
r(c) = 0.1167 ft

Solution Method: Moench

S = 0.2745
ß = 2.296E-5
r(w) = 0.375 ft
alpha = 1.0E+30 sec^{-1}

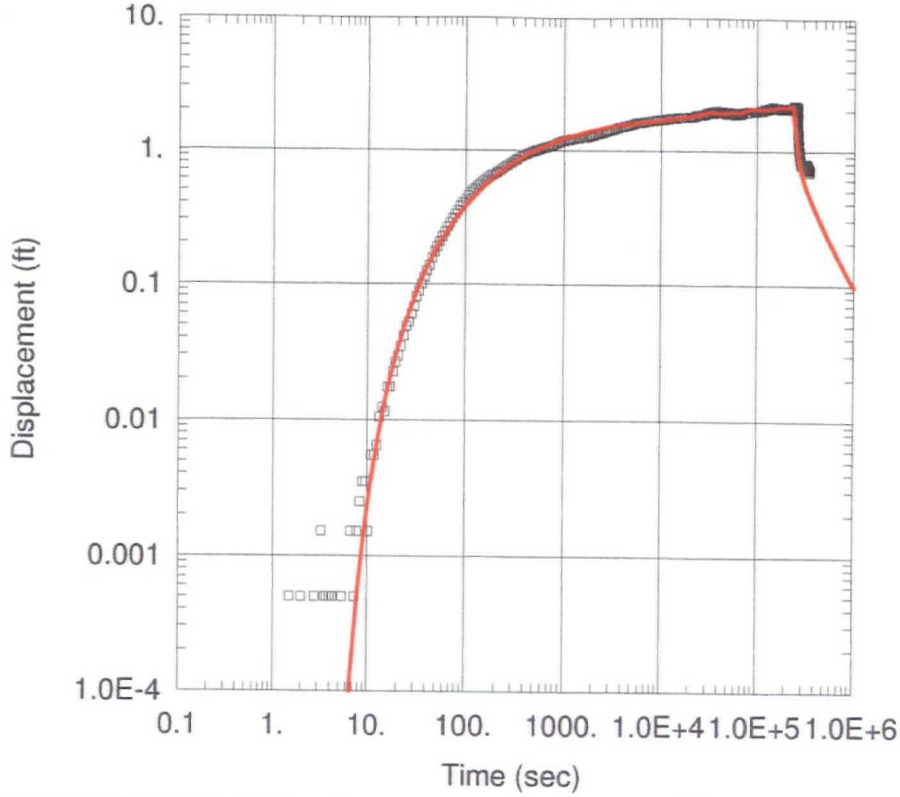


FIGURE 8: NEUMAN SOLUTION FOR E-OW-1S

Data Set: C:\FAA\Area E\Report\Figures\Figure 8 Neuman E-OW-1S.aqt
Date: 06/04/10 Time: 10:26:34

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ E-OW-1S	4.33	0

SOLUTION

Aquifer Model: Unconfined

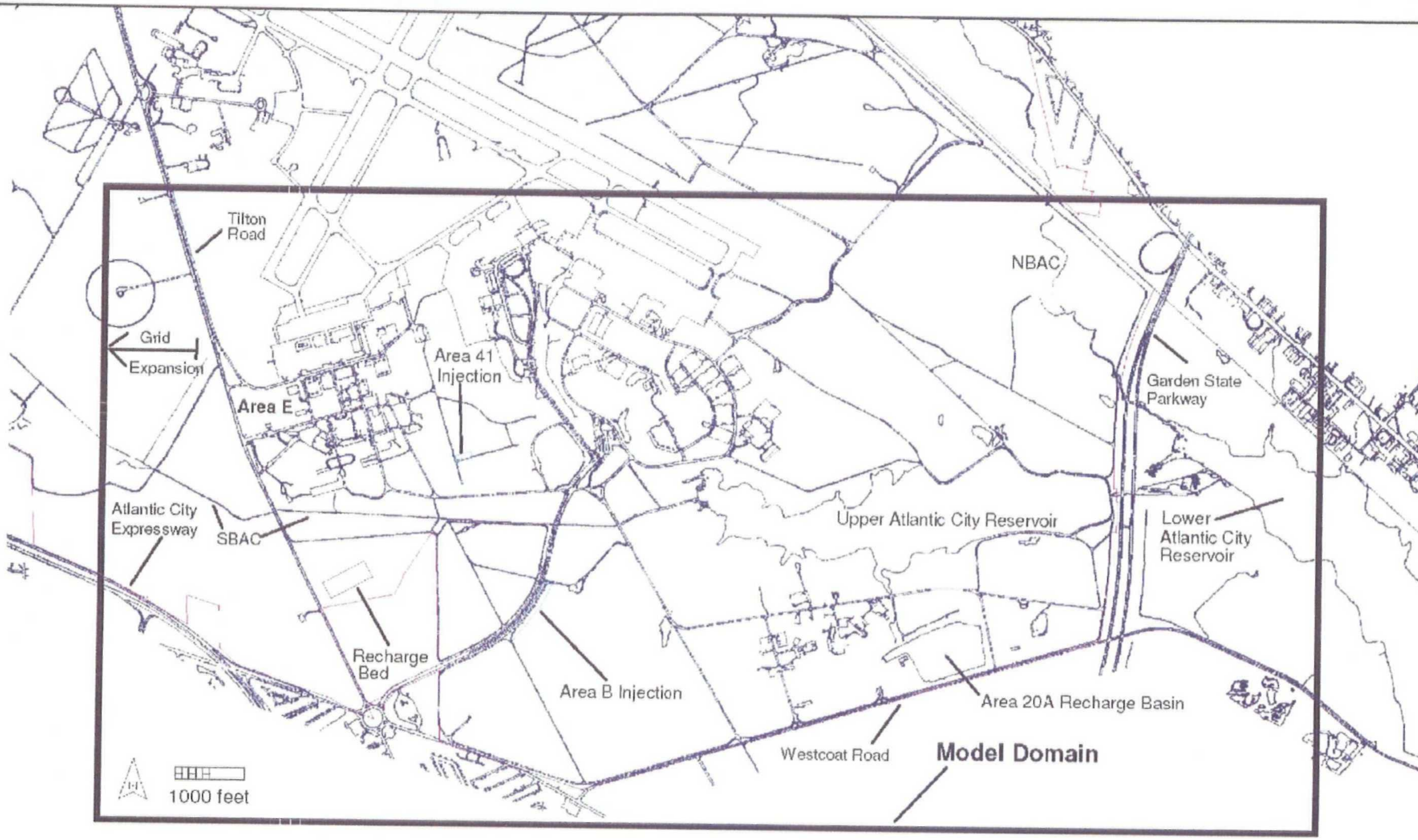
Solution Method: Neuman

T = 4.302 cm^2/sec

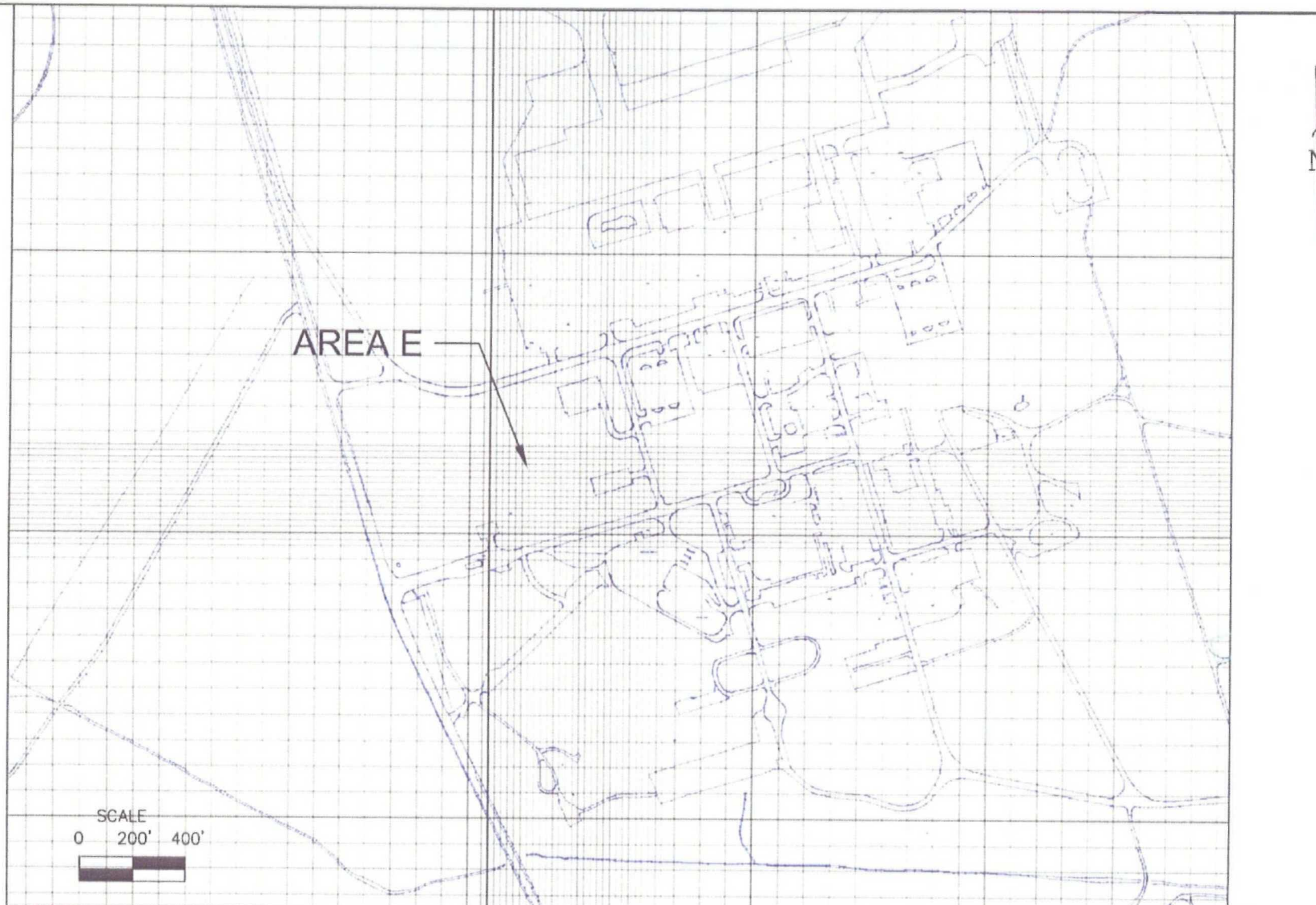
S = 0.03733

Sy = 0.3552

ß = 0.003061



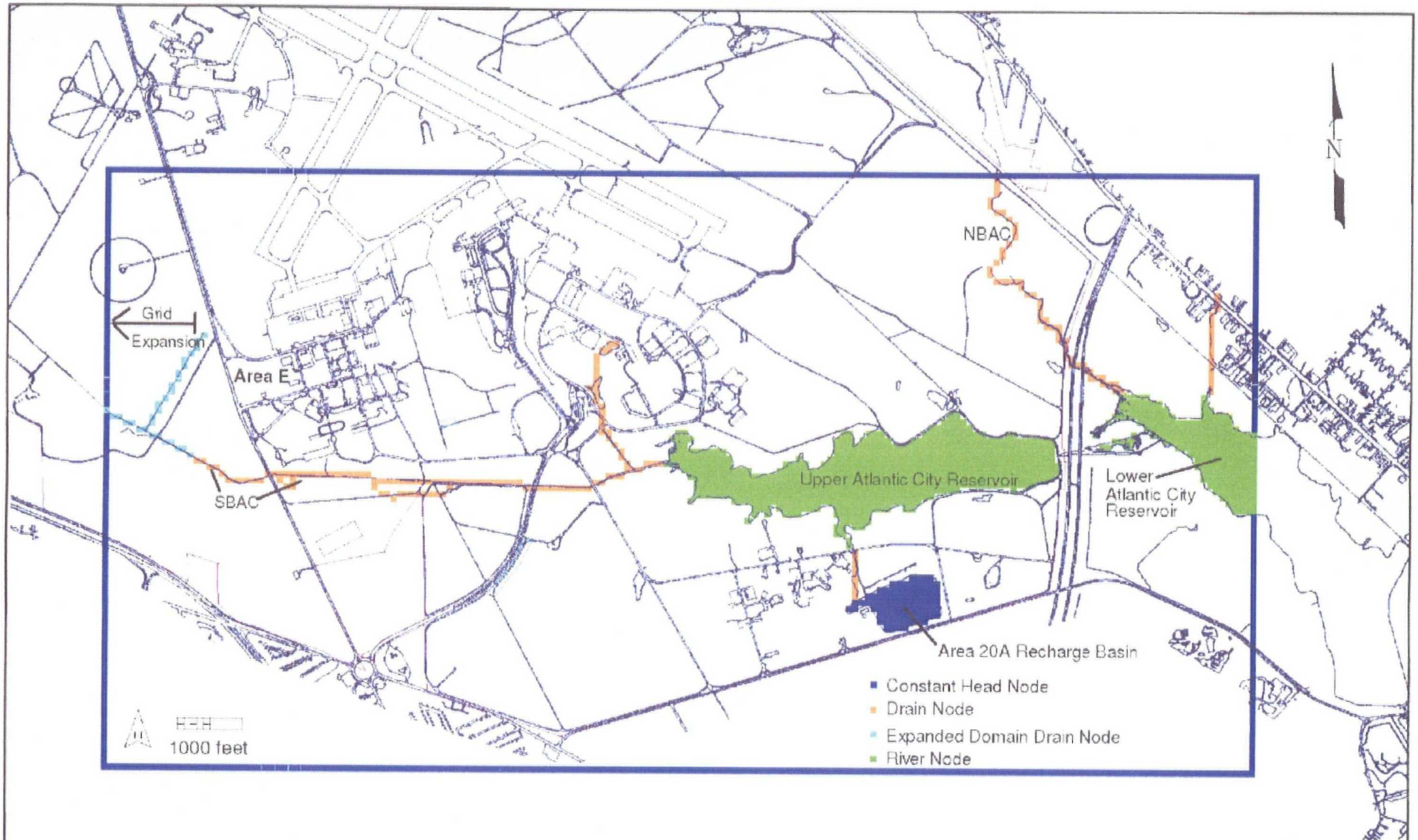
MODEL DOMAIN			
FAA WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INT'L AIRPORT, NJ			
PROJECT NO.: 162662	DWG FILE: Fig. X1 – Model Domain		
DRAWN BY: KS	DATE 05/25/10		
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 9	



MODEL GRID

FAA WILLIAM J. HUGHES
TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT, NJ

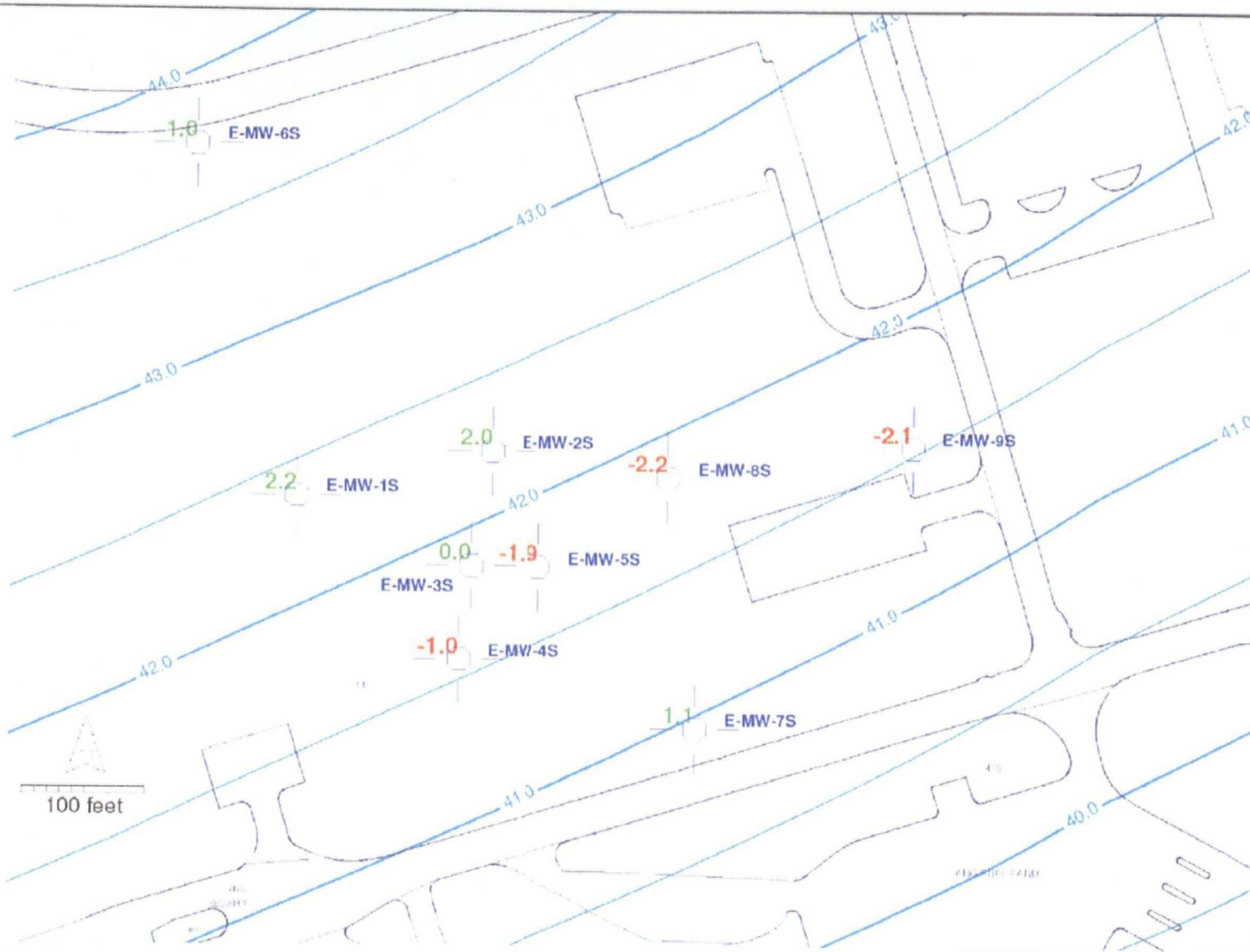
PROJECT NO.:	162662	DWG FILE: Fig. X2 - Model Grid	
DRAWN BY:	KS	DATE 05/25/10	
TRC		7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 10



SURFACE WATER AND SHALLOW AQUIFER BOUNDARY CONDITIONS

FAA WILLIAM J. HUGHES
TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT, NJ

PROJECT NO.:	162662	DWG FILE: Fig. X3 -SW & Sa Cond	
DRAWN BY:	KS	DATE	05/27/10
TRC		7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 11



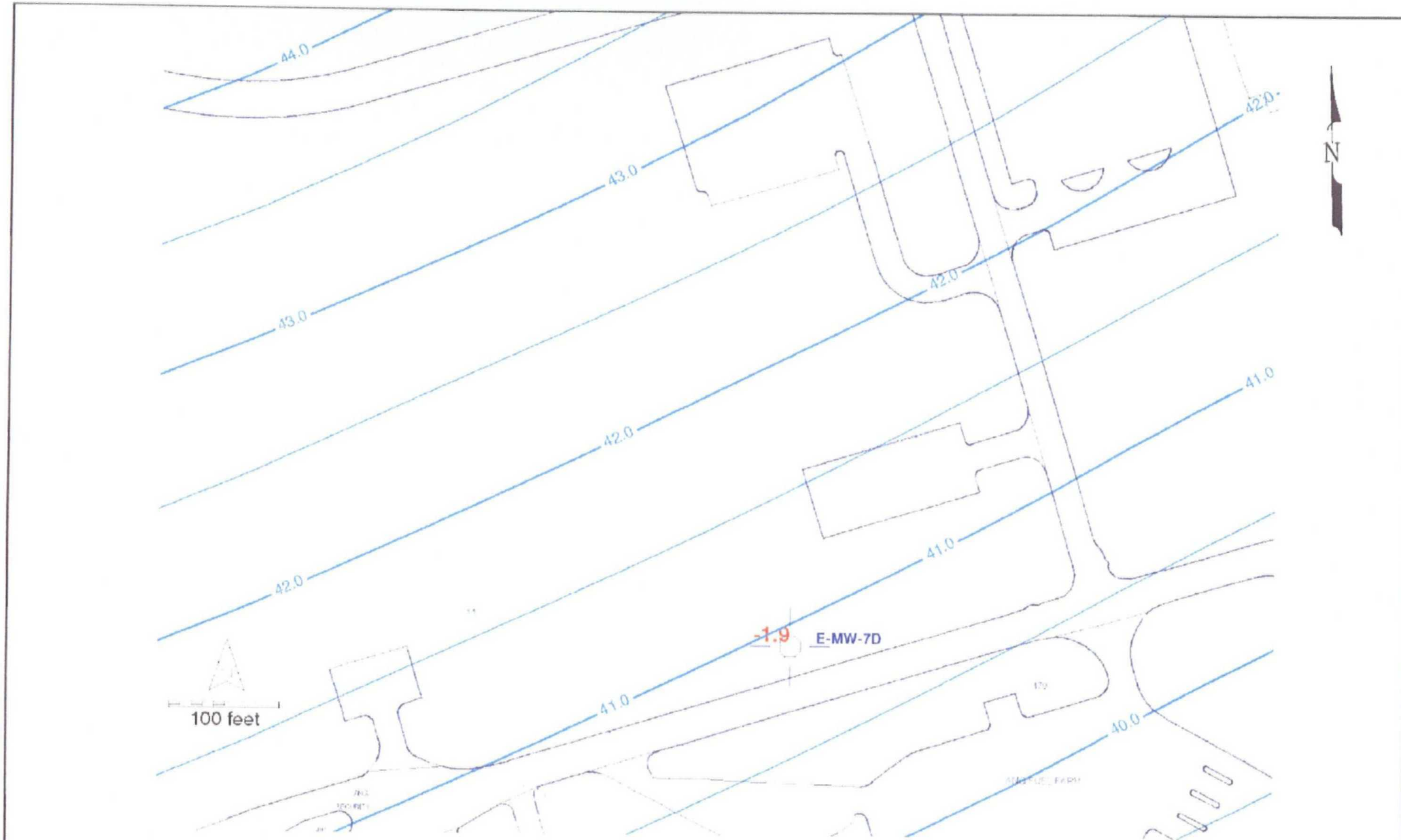
LEGEND:

E-MW-1S — Area E Monitoring Wells

-2.2 — Errors Between Simulated and Water Levels Measured Nov., 2009 - Simulated Higher

-2.2 — Errors Between Simulated and Water Levels Measured Nov., 2009 - Simulated Lower

BASELINE SIMULATION RESULTS			
FAA WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INT'L AIRPORT, NJ			
PROJECT NO.: 162662	DWG FILE: Fig. X3 –SW & So Cond.		
DRAWN BY: KS	DATE 05/27/10		
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 12A	



LEGEND:

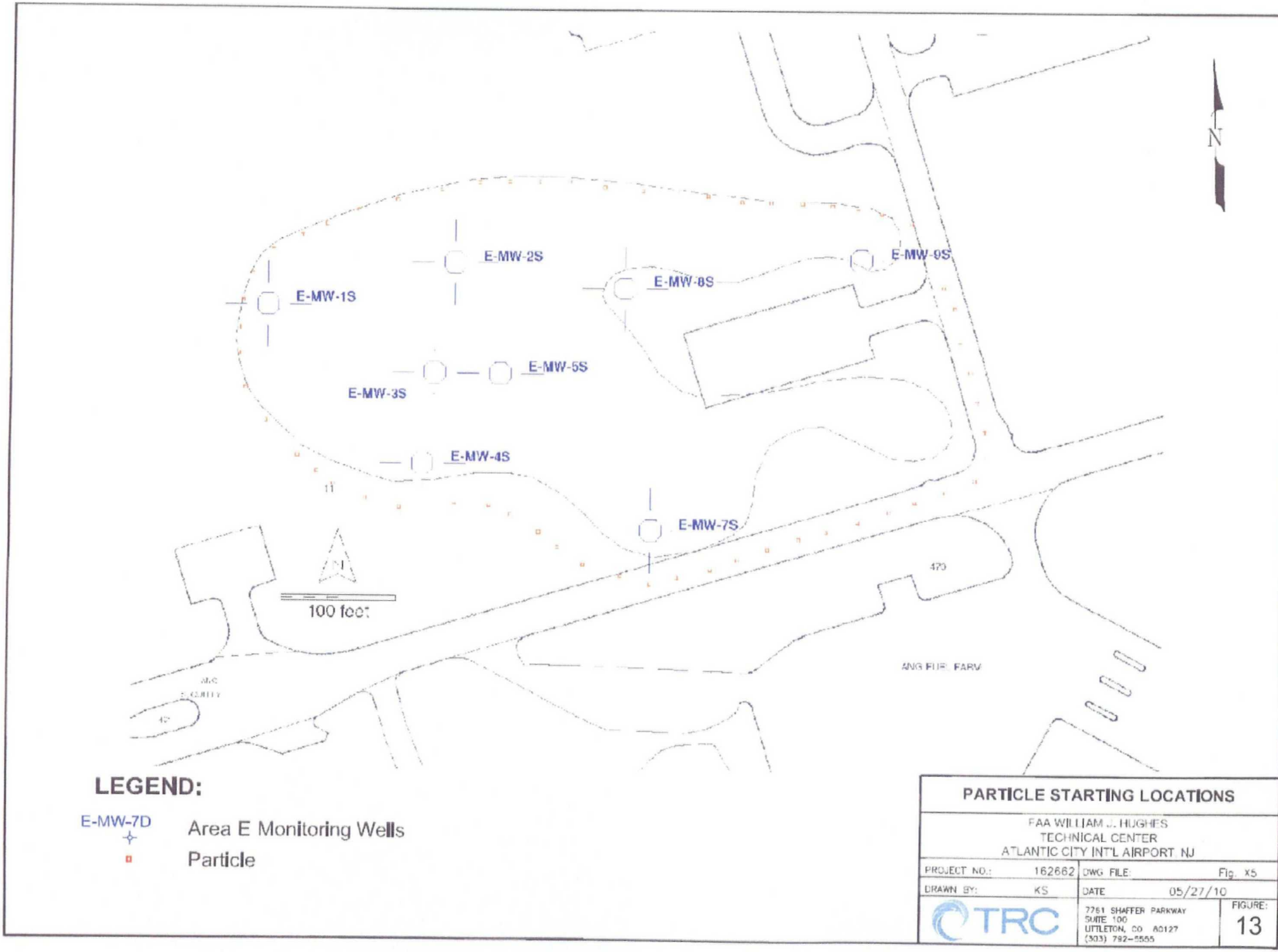
E-MW-7D — Area E Monitoring Wells

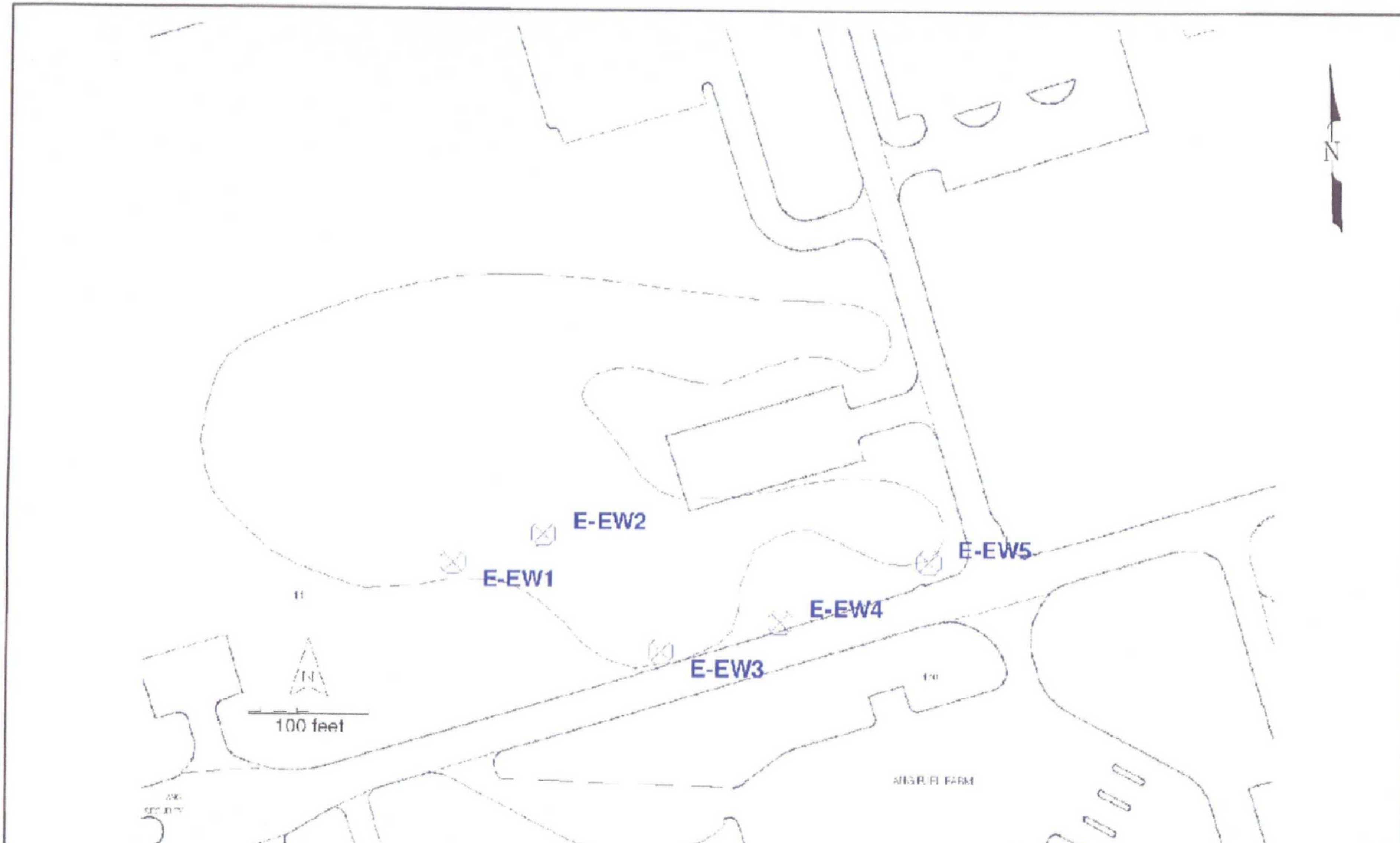
-2.2 — Errors Between Simulated and Water Levels Measured Nov., 2009 - Simulated Higher

BASELINE SIMULATION RESULTS

FAA WILLIAM J. HUGHES
TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT, NJ

PROJECT NO.:	162662	DWG FILE: Fig. X3 –SW & Sa Cond.	
DRAWN BY:	KS	DATE	05/27/10
TRC		7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 12B


E-MW-1S
E-MW-2S
E-MW-3S
E-MW-4S
E-MW-5S
E-MW-7S
E-MW-8S
E-MW-9S
N
N
100 feet
470
ANG FUEL FARM
LEGEND:
E-MW-7D Area E Monitoring Wells
Particle
PARTICLE STARTING LOCATIONS
FAA WILLIAM J. HUGHES
TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT NJ
PROJECT NO.: 162682
DWG FILE: Fig. X5
DRAWN BY: KS
DATE 05/27/10
TRC
7761 SHAFFER PARKWAY
SUITE 100
LITTLETON, CO 80127
(303) 792-5555
FIGURE: 13



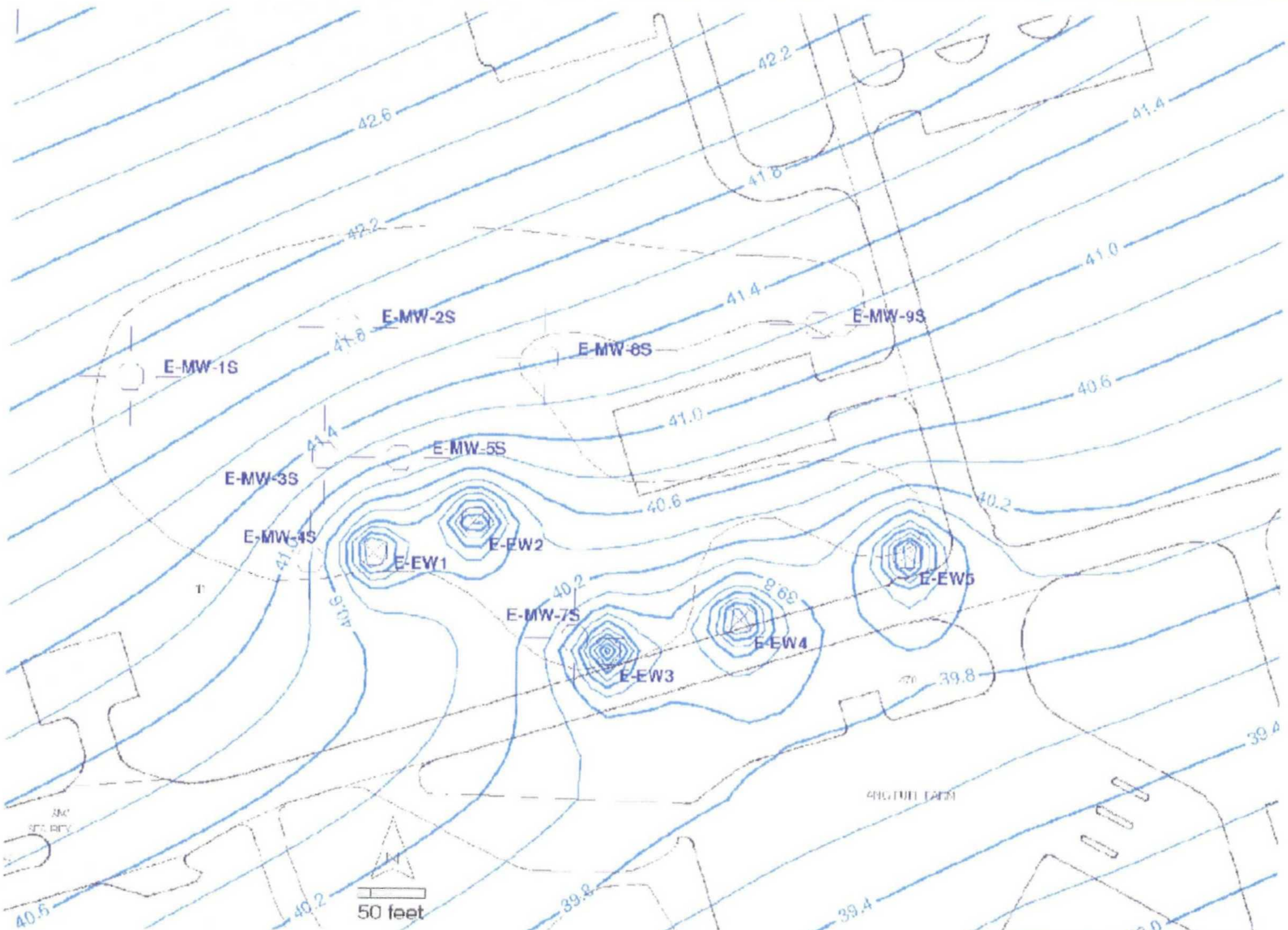
LEGEND:

E-EW1 — Extraction Wells

EXTRACTION WELL LOCATIONS

FAA WILLIAM J. HUGHES
TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT, NJ

PROJECT NO.: 162662	DWG FILE: Fig. X6		
DRAWN BY: KS	DATE 05/27/10		
TRC	7751 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 14	

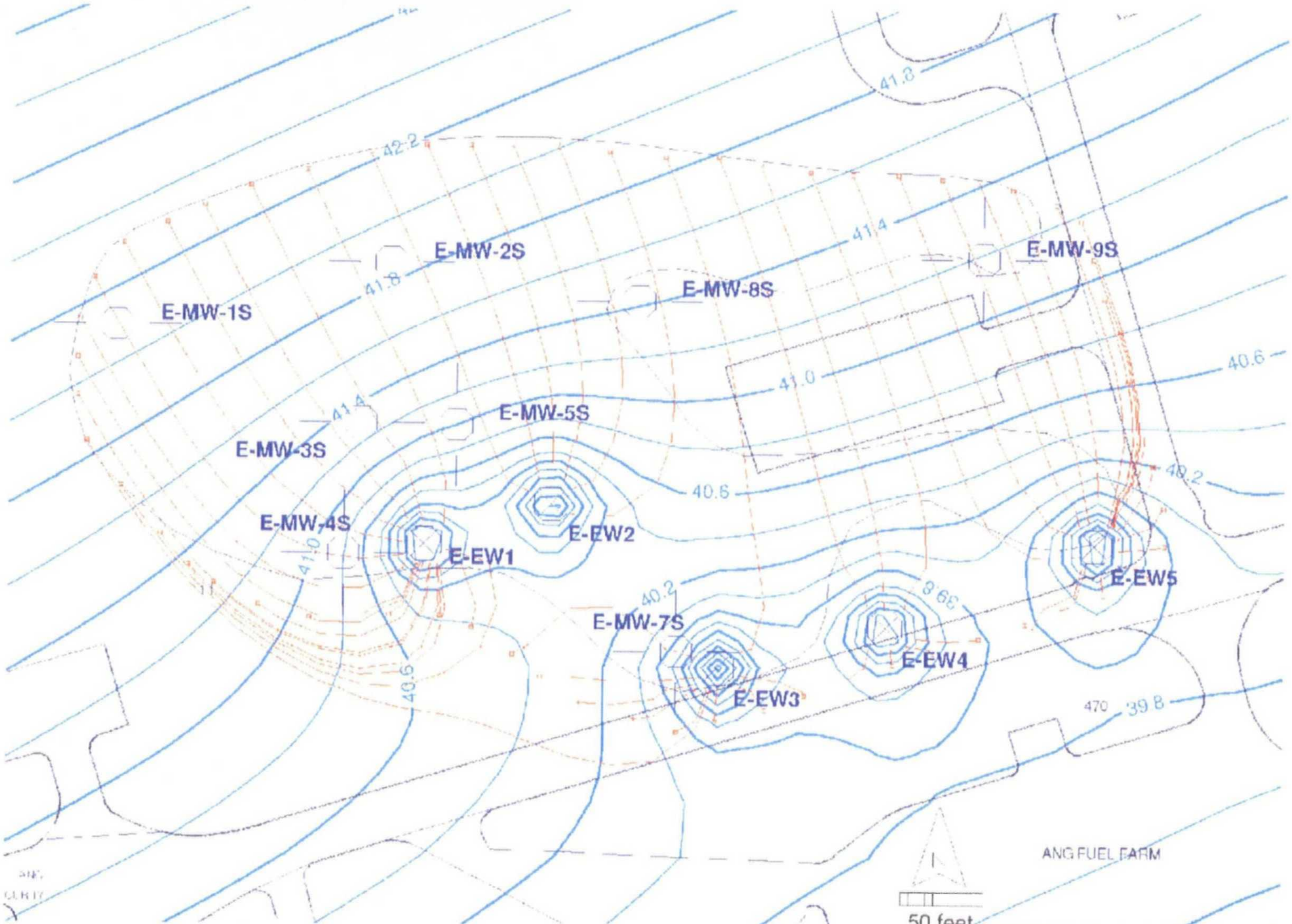


LEGEND:

E-MW-7D Area E Monitoring Wells

E-EW1 Area E Extraction Wells

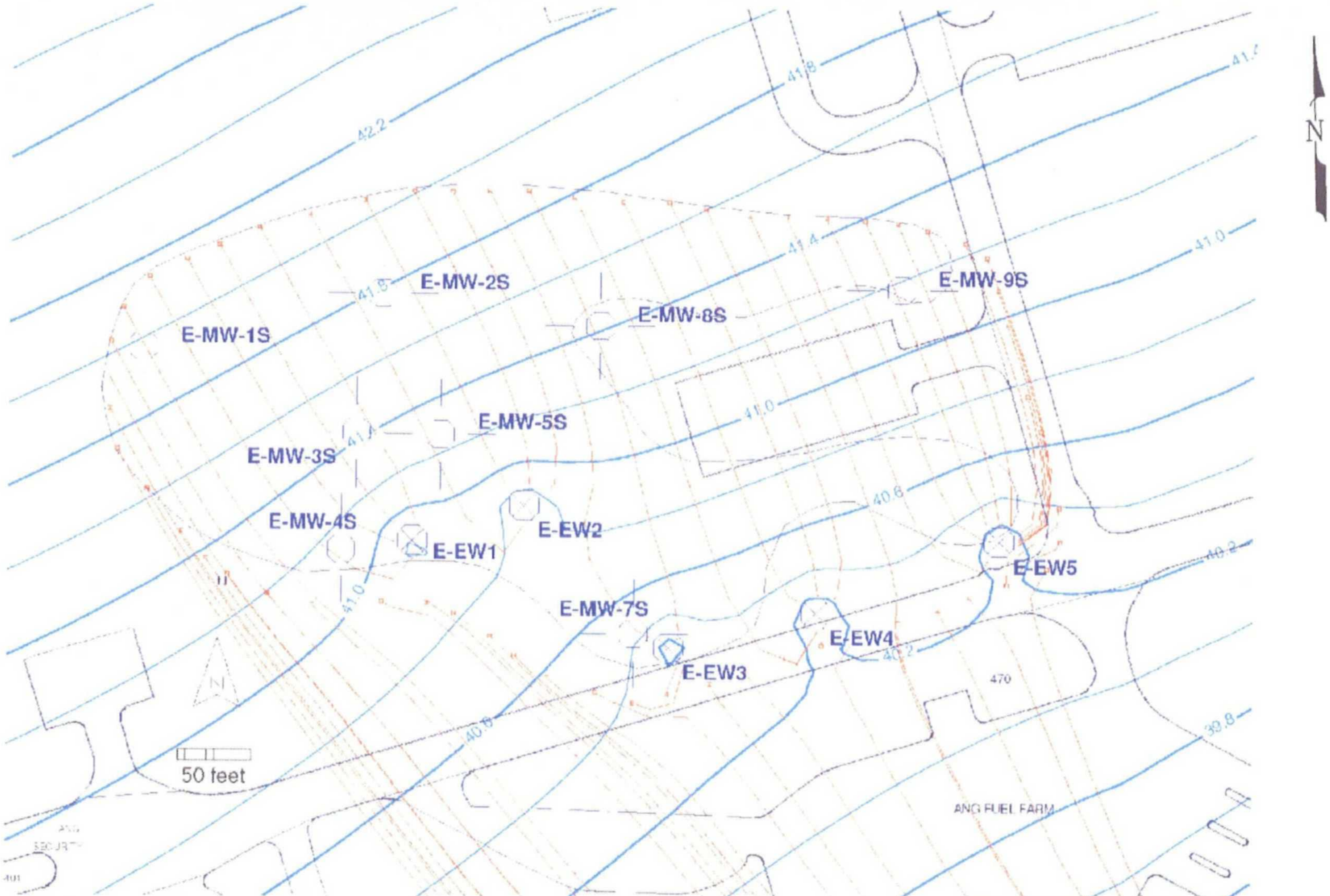
PUMPING CONES OF DEPRESSION			
FAA WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INT'L AIRPORT, NJ			
PROJECT NO.: 162662	DWG FILE: Fig. X7		
DRAWN BY: KS	DATE 05/27/10		
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 15	



LEGEND:

E-MW-1S	Area E Monitoring Wells
E-EW1	Area E Extraction Wells

PARTICLE TRACKS			
FAA WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INT'L AIRPORT, NJ			
PROJECT NO.: 162662	DWG FILE: Fig. X8		
DRAWN BY: KS	DATE 05/27/10		
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 16	



LEGEND:

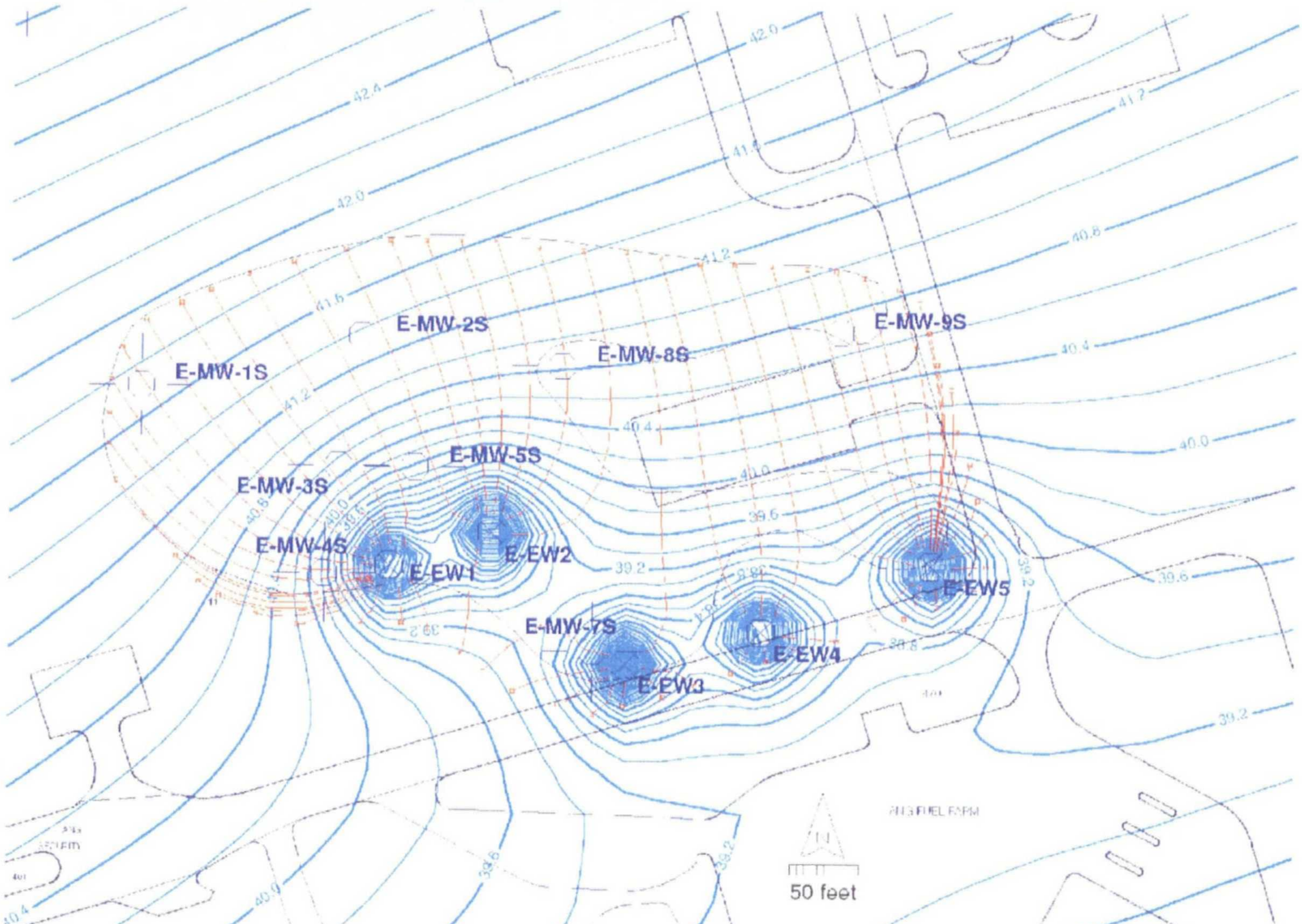
E-MW-1S — Area E Monitoring Wells

E-EW1 — Area E Extraction Wells

SENSITIVITY SIMULATION: HIGH HYDRAULIC CONDUCTIVITY, 5 gpm

FAA WILLIAM J. HUGHES
TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT, NJ

PROJECT NO.:	162662	DWG FILE:	Fig. X9
DRAWN BY:	KS	DATE	05/27/10
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE:	17

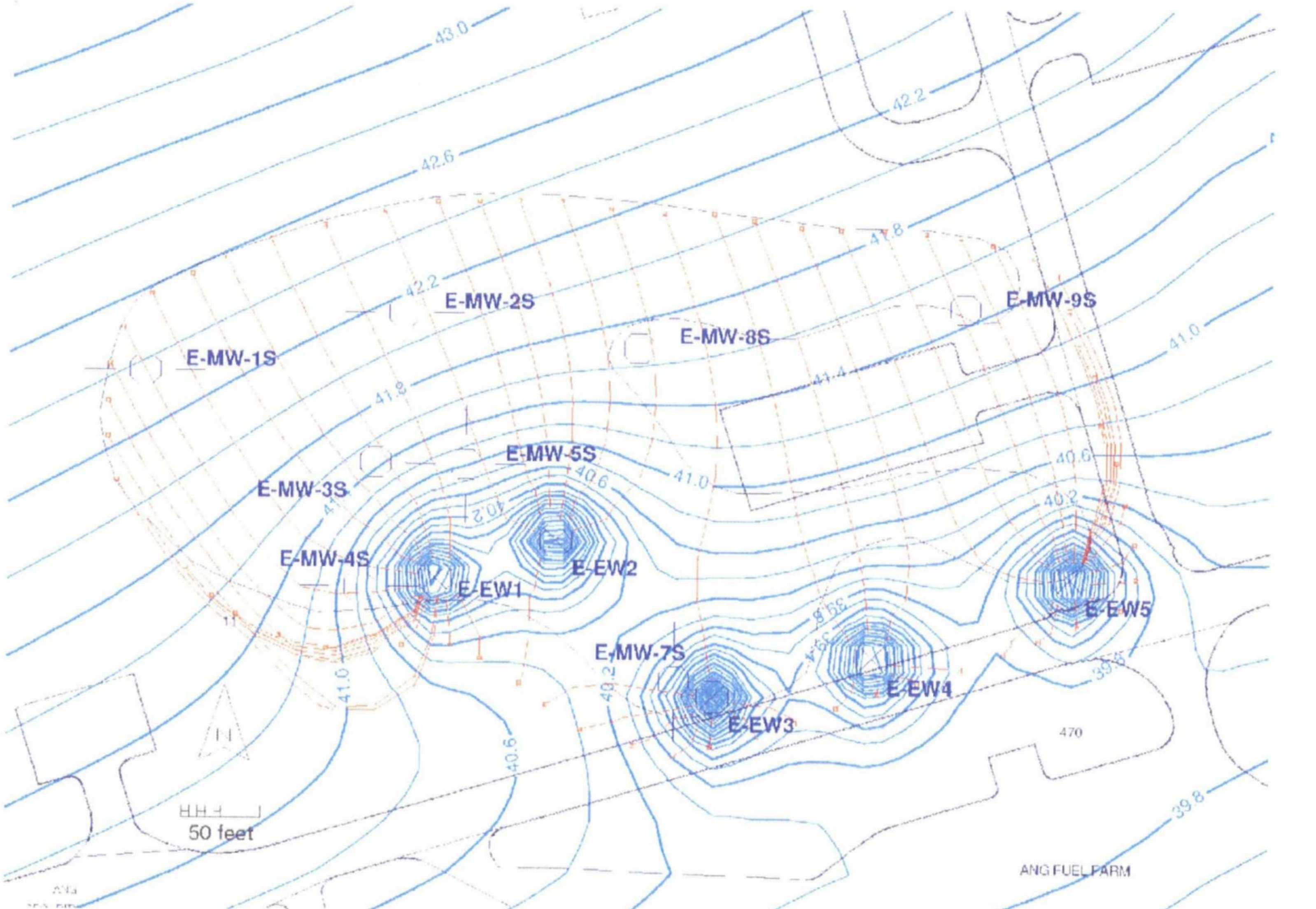


LEGEND:

E-MW-1S — Area E Monitoring Wells

E-EW1 — Area E Extraction Wells

SENSITIVITY SIMULATION: HIGH HYDRAULIC CONDUCTIVITY, 12 gpm			
FAA WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INT'L AIRPORT, NJ			
PROJECT NO.: 162662	DWG FILE:	Fig. X10	
DRAWN BY: KS	DATE	05/27/10	
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555		FIGURE: 18



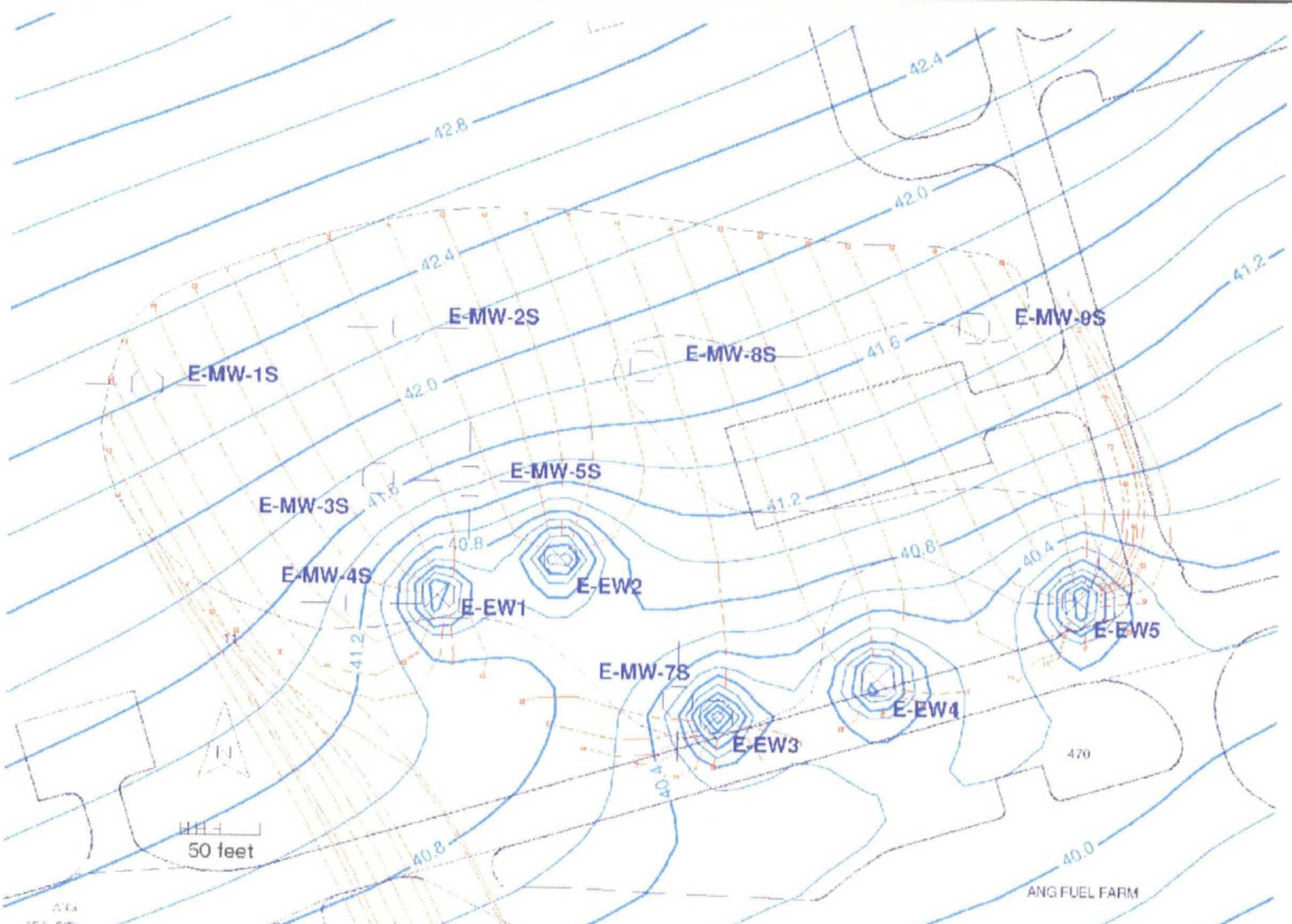
LEGEND:

E-MW-1S	Area E Monitoring Wells
E-EW1	Area E Extraction Wells

SENSITIVITY SIMULATION: LOW HYDRAULIC CONDUCTIVITY, 2 gpm

FAA WILLIAM J. HUGHES TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT, NJ

PROJECT NO.:	162662	DWG FILE:	Fig. X11
DRAWN BY:	KS	DATE	05/27/10
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE:	19

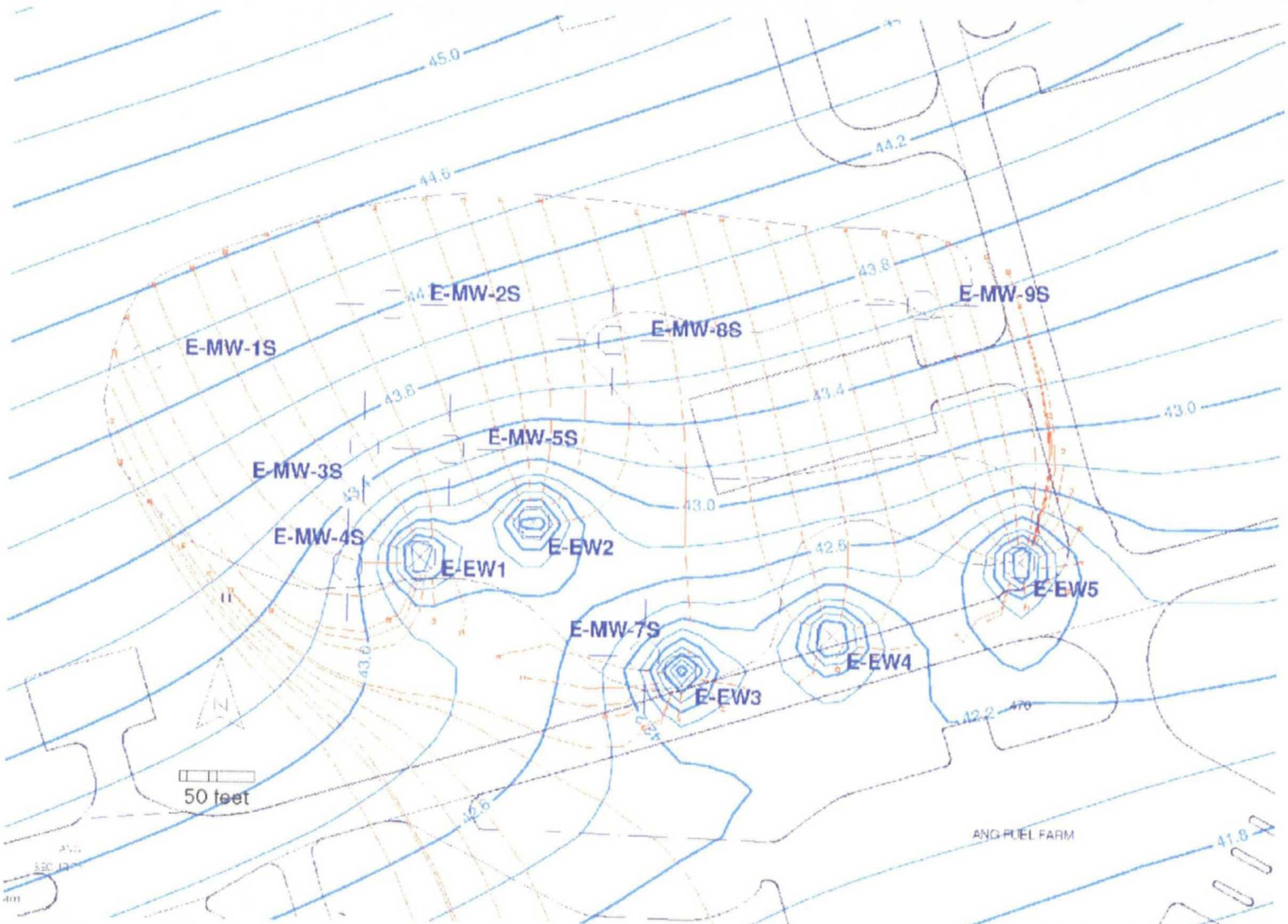


LEGEND:

E-MW-1S — Area E Monitoring Wells

E-EW1 — Area E Extraction Wells

SENSITIVITY SIMULATION: LOW HYDRAULIC CONDUCTIVITY, 1 gpm			
FAA WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INT'L AIRPORT, NJ			
PROJECT NO.: 162662	DWG FILE: Fig. X12		
DRAWN BY: KS	DATE 05/27/10		
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 20	

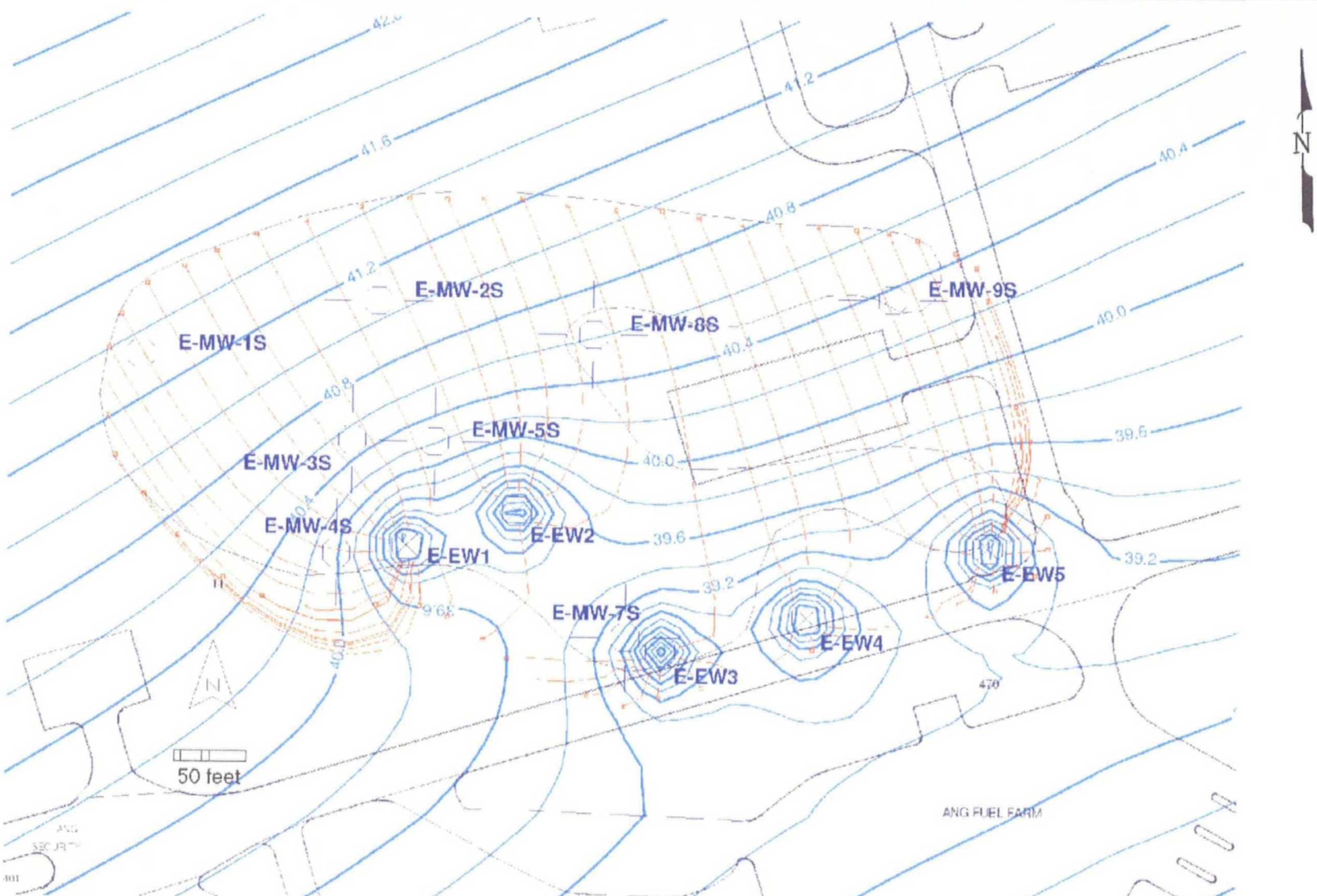


LEGEND:

E-MW-1S — Area E Monitoring Wells

E-EW1 — Area E Extraction Wells

SENSITIVITY SIMULATION: HIGH RECHARGE RATE			
FAA WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INT'L AIRPORT, NJ			
PROJECT NO.: 162662	DWG FILE: Fig. X13		
DRAWN BY: KS	DATE 05/27/10		
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 21	



LEGEND:

E-MW-1S Area E Monitoring Wells

E-EW1 Area E Extraction Wells

SENSITIVITY SIMULATION: LOW RECHARGE RATE

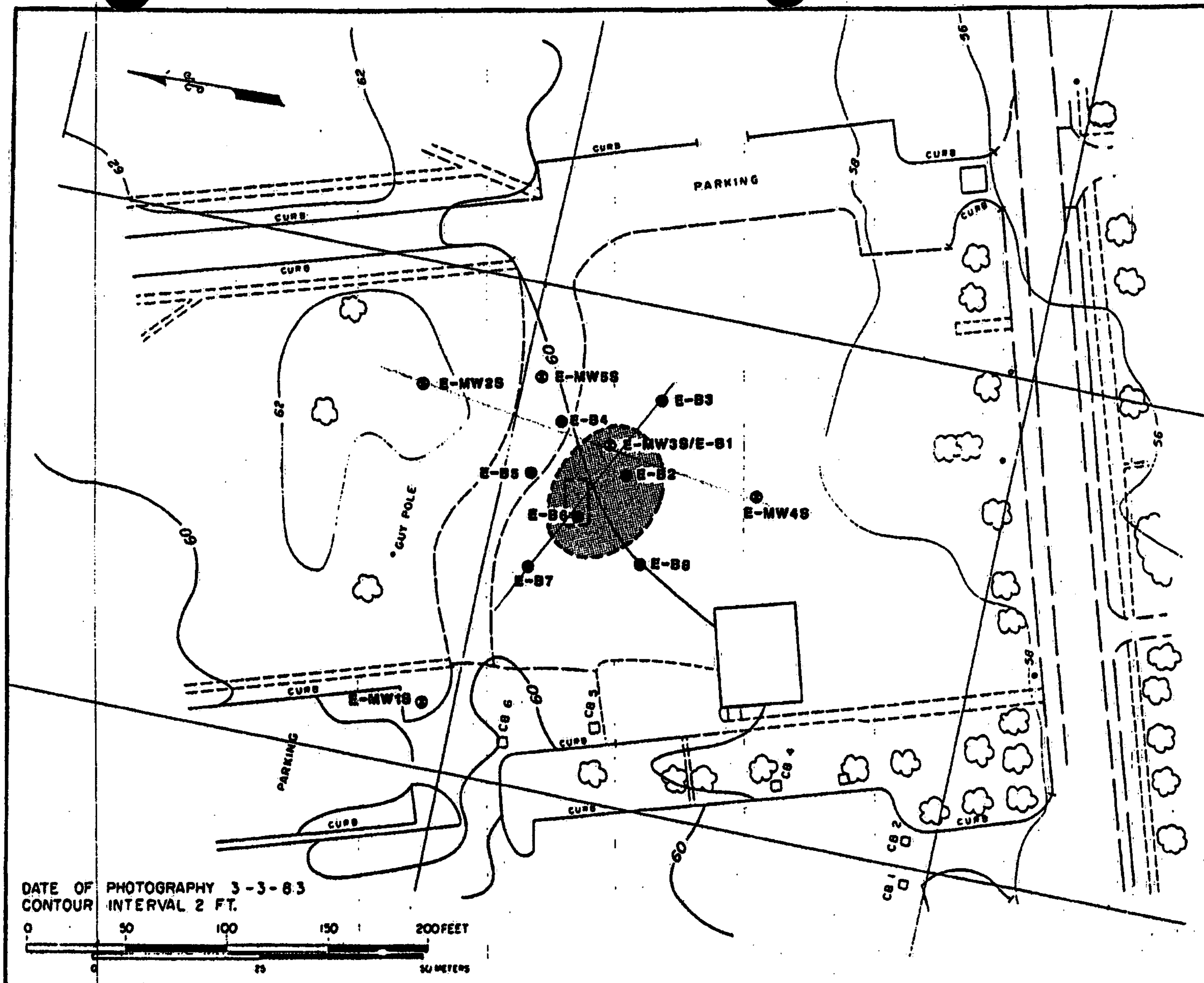
FAA WILLIAM J. HUGHES TECHNICAL CENTER
ATLANTIC CITY INT'L AIRPORT, NJ

PROJECT NO.: 162662	DWG FILE: Fig. X14		
DRAWN BY: KS	DATE 05/27/10		
TRC	7761 SHAFFER PARKWAY SUITE 100 LITTLETON, CO 80127 (303) 792-5555	FIGURE: 22	

APPENDIX A

AREA E - WELL CONSTRUCTION and LITHOLOGY LOGS

1980s LOGS



LEGEND

- MONITORING WELL
- BORING
- EXTENT OF SUBSURFACE SOIL STAINING

TRC Environmental Consultants, Inc.

FAA TECHNICAL CENTER

ENVIRONMENTAL INVESTIGATIVE/FEASIBILITY STUDY

FIGURE 11-5.

EXTENT OF FREE PRODUCT - AREA E

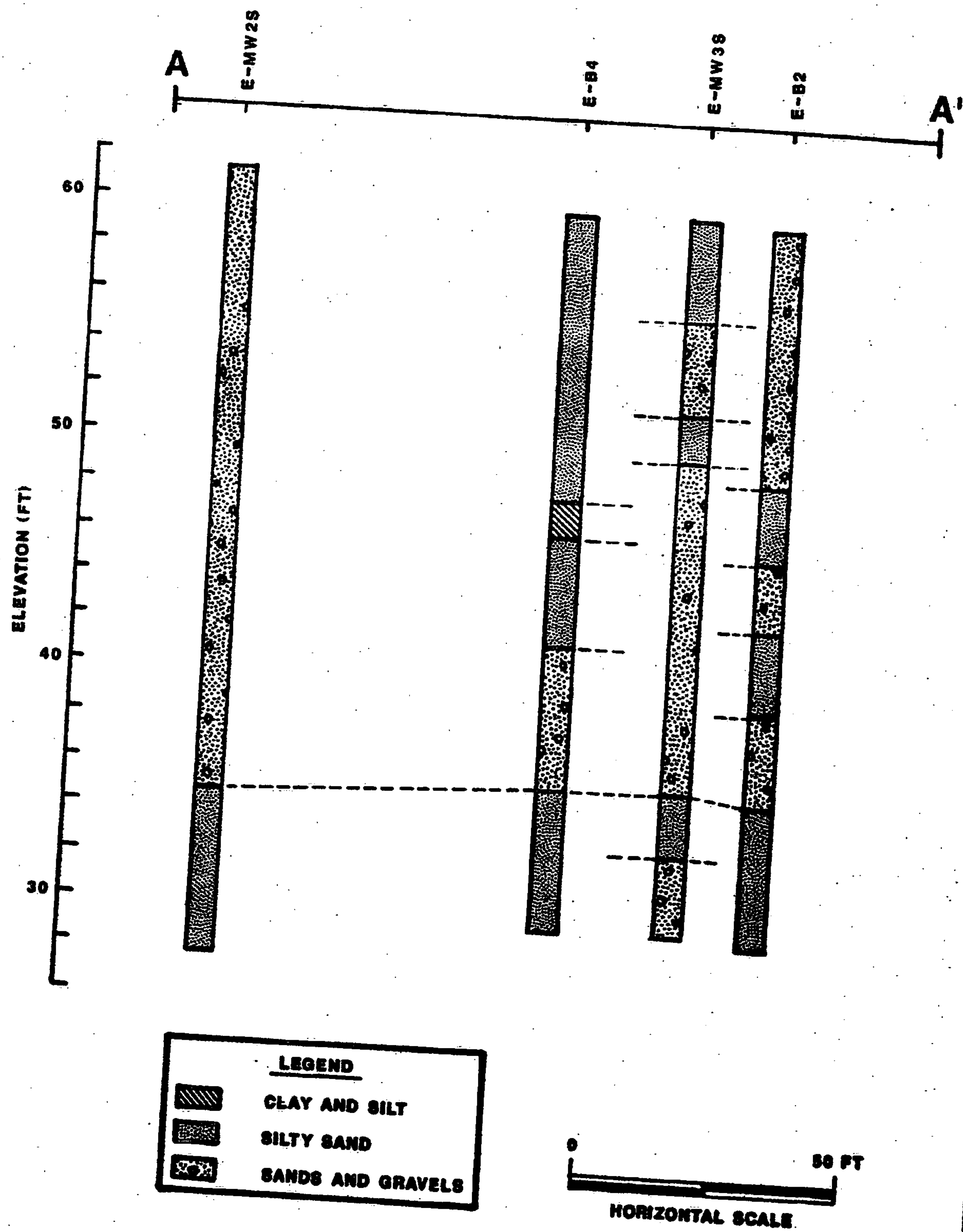
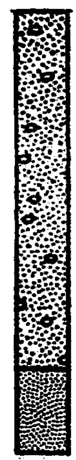


FIGURE 18-4. CROSS-SECTION A-A' -- SITE E

BORING NO.:	E-85	BORING DEPTH:	20 FT	DATE STARTED:	10/12/88
PROJECT NO.:	3639-NB1	CONTRACTOR:	EMPIRE SOILS	DATE COMPLETED:	10/12/88
PROJECT:	FAA	DRILLERS:	ALBERALLA/WALKER	GROUND ELEVATION:	61 FT
CLIENT:	FAA	TRC INSPECTOR:	ZLOTNICK, HANKINS	LOCATION:	N 222,486
LOCATION:	PLEASANTVILLE, NJ	DRILLING METHOD:	4-1/4" HOLLOW STEM AUGERS		E 2,023,154

DEPTH (FT)	BLOWS	OVA (PPM)	SOIL DESCRIPTION	LITHOLOGY
0				0.0
			AUGERED TO DEPTH OF 10 FEET	
10 - 12	10 11 15 15	3	FINE TO MEDIUM SAND, LITTLE SILT, BROWN, DRY, NO ODOR	
12 - 14	9 11 13 16	1	SAME AS ABOVE	
14 - 16	9 9 9 8	1	FINE TO COARSE SAND, LITTLE GRAVEL AND SILT, RED-BROWN, DRY, NO ODOR, 14.0-15.0: FINE TO MEDIUM SAND, LIGHT BROWN, 15.0-16.0	
16 - 18	6 7 5 7	1	FINE TO MEDIUM SAND AND SILT, LIGHT BROWN-GRAY, MOIST, NO ODOR	16.0
18 - 20	13 9 11 9	2	SAME AS ABOVE, WET, 18.0-19.5: FINE TO COARSE SAND AND GRAVEL, LITTLE SILT, WET, 19.5-20.0	
				20.0
			END OF BORING AT 20 FT	

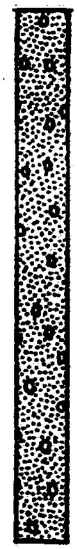


BORING NO.:	E-B6	BORING DEPTH:	24 FT	DATE STARTED:	10/12/88
PROJECT NO.:	3639-N81	CONTRACTOR:	EMPIRE SOILS	DATE COMPLETED:	10/12/88
PROJECT:	FAA	DRILLERS:	ALBERALLA/WALKER	GROUND ELEVATION:	61 FT
CLIENT:	FAA.	TRC INSPECTOR:	ZLOTNICK/HANKINS	LOCATION:	N 222.460
LOCATION:	PLEASANTVILLE, NJ	DRILLING METHOD:	4-1/4" HOLLOW STEM AUGERS		E 2.023.140

DEPTH (FT)	BLOWS	OVA (PPM)	SOIL DESCRIPTION
0			AUGERED TO DEPTH OF 10 FEET SOIL FROM 3-10 FT DEPTH STAINED BLACK WITH PETROLEUM ODOR
10 - 12	2 3 2 2	250	FINE TO MEDIUM SAND, STAINED BLACK, DEFINITE PETROLEUM ODOR, WET
12 - 14	4 8 11 12	125	SAME AS ABOVE
14 - 16	7 9 12 12	100	SAME AS ABOVE
16 - 18	9 13 13 11	72	SAME AS ABOVE
18 - 20	11 11 10 12	3	SAME AS ABOVE, 18.0-19.2; FINE TO COARSE SAND, LITTLE SILT AND GRAVEL, LIGHT BROWN, NO STAINING, SLIGHT PETROLEUM ODOR, 19.2-20.0
20 - 22	4 6 7 8	6	FINE TO COARSE SAND AND GRAVEL, LITTLE SILT, BROWN, NO STAINING, NO ODOR
22 - 24	8 9 12 11	5	FINE TO COARSE SAND, LITTLE SILT, REDDISH BROWN, WET, NO STAINING OR ODOR

LITHOLOGY

0.0



24.0

END OF BORING AT 24 FT

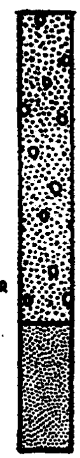
BORING NO.: E-B7	BORING DEPTH: 20 FT	DATE STARTED: 10/12/88	
PROJECT NO.: 3639-NB1	CONTRACTOR: EMPIRE SOILS	DATE COMPLETED: 10/12/88	
PROJECT: FAA	DRILLERS: ALBERALLA/WALKER	GROUND ELEVATION: 61 FT	
CLIENT: FAA	TRC INSPECTOR: ZLOTNICK/HANKINS	LOCATION: N 222,480	
LOCATION: PLEASANTVILLE, NJ	DRILLING METHOD: 4-1/4" HOLLOW STEM AUGERS	E 2,023,108	

DEPTH (FT)	BLOWS	OVA (PPM)	SOIL DESCRIPTION	LITHOLOGY
0				0.0
			AUGERED TO DEPTH OF 10 FT	
10 - 12	13 10 12 11	2	FINE TO COARSE SAND, LITTLE GRAVEL AND SILT, LIGHT BROWN, DRY, NO ODOR	
12 - 14	16 15 15 13	3	SAME AS ABOVE	
14 - 16	8 8 10 9	2	FINE TO MEDIUM SAND, LITTLE SILT, BROWN, DRY, NO ODOR	
16 - 18	8 7 6 5	1	FINE TO MEDIUM SAND AND SILT, BROWN, WET, NO ODOR	16.0
18 - 20	10 8 9 9	1	MEDIUM TO COARSE SAND, LITTLE FINE SAND AND SILT, RED-BROWN, WET, NO ODOR	18.0
				20.0

END OF BORING AT 20 FT

BORING NO.:	E-B8	BORING DEPTH:	20 FT	DATE STARTED:	10/12/88
PROJECT NO.:	3639-NB1	CONTRACTOR:	EMPIRE SOILS	DATE COMPLETED:	10/12/88
PROJECT:	FAA	DRILLERS:	ALBERALLA/WALKER	GROUND ELEVATION:	61 FT
CLIENT:	FAA	TRC INSPECTOR:	ZLOTNICK/HANKINS	LOCATION:	N 222,424
LOCATION:	PLEASANTVILLE, NJ	DRILLING METHOD:	4-1/4" HOLLOW STEM AUGERS		E 2,023,120

DEPTH (FT)	BLOWS	OVA (PPM)	SOIL DESCRIPTION	LITHOLOGY
0				0.0
10 - 12	8 8 10 10	2	FINE TO MEDIUM SAND, LITTLE SILT, BROWN, DRY, NO ODOR	
12 - 14	8 9 12 11	2	SAME AS ABOVE, 12.0-13.7: FINE TO MEDIUM SAND, LITTLE SILT, BROWN, NO ODOR	
14 - 16	3 8 9 8	4	FINE TO MEDIUM SAND AND SILT, LIGHT BROWN, DRY, NO ODOR	14.0
16 - 18	5 8 6 4	2	SAME AS ABOVE	
18 - 20	7 5 7 7	2	SAME AS ABOVE	
				20.0

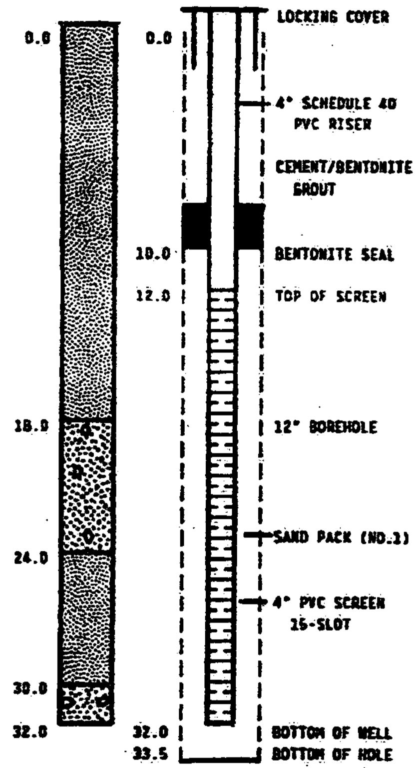


END OF BORING AT 20 FT

BORING NO.:	E-MW4S	CONTRACTOR:	EMPIRE SOILS	DATE STARTED:	10/14/88
PROJECT NO.:	3639-N81	DRILLERS:	ALBERALLA/WALKER	DATE COMPLETED:	10/14/88
PROJECT:	FAA	TRC INSPECTOR:	ZLOTNICK	WATER TABLE LEVEL:	21.86 FT (12/88)
CLIENT:	FAA	DRILLING METHOD:	6-1/4" HOLLOW STEM AUGERS	LOCATION:	N 223,375
LOCATION:	PLEASANTVILLE,NJ	GROUND ELEVATION:	58.70 FT		E 2,023,167
BORING DEPTH:	33.5 FT	CASING ELEVATION:	60.52 FT	NJDEP PERMIT NUMBER:	3610786-7

DEPTH (FT)	BLOWS	OVA (PPM)	SOIL DESCRIPTION
0			
5 - 7	4 3 3 3	1	FINE TO MEDIUM SAND, SOME SILT, SOME GRAVEL, BROWN, MOIST
10 - 12	4 8 9 11	2	FINE TO MEDIUM SAND, SOME SILT, BROWN, MOIST
15 - 17	7 6 6 3	2	FINE TO MEDIUM SAND, SOME SILT, TRACE GRAVEL, WET BELOW 16.5 FT
20 - 22	5 6 7 7	4	FINE TO COARSE SAND, LITTLE SILT, BROWN GRADING TO DARK REDDISH BROWN, WET
25 - 27	4 4 4 4	3	FINE TO MEDIUM SAND, SOME SILT, BROWN, WET
30 - 32	6 8 18 35	6	FINE TO MEDIUM SAND, LITTLE SILT, BROWN, WET: LITTLE GRAVEL, 31.0-32.0
			AUGERED TO END OF BORING AT 33.5 FT

LITHOLOGY WELL CONSTRUCTION

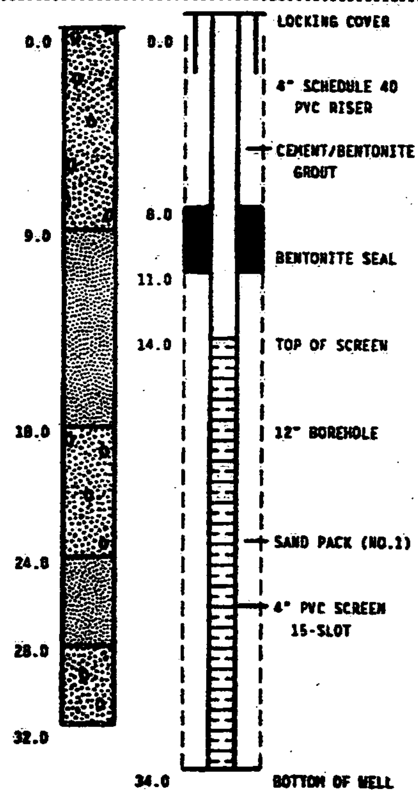


BORING NO.:	E-MW5S	CONTRACTOR:	EMPIRE SOILS	DATE STARTED:	10/17/88
PROJECT NO.:	3639-N81	DRILLERS:	ALBERALLA/WALKER	DATE COMPLETED:	10/17/88
PROJECT:	FAA	TRC INSPECTOR:	ZLOTNICK/FRANCE	WATER TABLE LEVEL:	21.95 FT (12/88)
CLIENT:	FAA	DRILLING METHOD:	6-1/4" HOLLOW STEM AUGERS	LOCATION:	N 222.4[illegible]5
LOCATION:	PLEASANTVILLE, NJ	GROUND ELEVATION:	59.70 FT		E 2,023,206
BORING DEPTH:	34 FT	CASING ELEVATION:	60.57 FT	NJDEP PERMIT NUMBER:	3610787-5

DEPTH (FT)	BLOWS	OVA (PPM)	SOIL DESCRIPTION
0			
5 - 7	25 27 21 30	2	MEDIUM TO COARSE SAND, SOME GRAVEL, TRACE CLAY, SLIGHTLY COHESIVE
10 - 12	7 11 10 8	2	FINE TO MEDIUM SAND AND SILT, LITTLE GRAVEL, DRY, 10.0-10.6; FINE TO COARSE SAND, SOME SILT, SOME GRAVEL, LIGHT BROWN, 10.6-12.0
15 - 17	3 5 6 4	1	MEDIUM SAND, SOME SILT, SOME FINE SAND, YELLOW BROWN, WET, SOMEWHAT COHESIVE, WET BELOW 15.5 FT
20 - 22	2 3 4 4	6	COARSE SAND, TRACE SILT, LITTLE GRAVEL, YELLOW, WET
25 - 27	1 1 2 5	4	FINE SAND AND SILT, COHESIVE, YELLOW-BROWN
30 - 32	2 4 8 12	3	FINE TO MEDIUM SAND, LIGHT YELLOW

AUGERED AHEAD TO END OF BORING AT 34 FT

LITHOLOGY WELL CONSTRUCTION

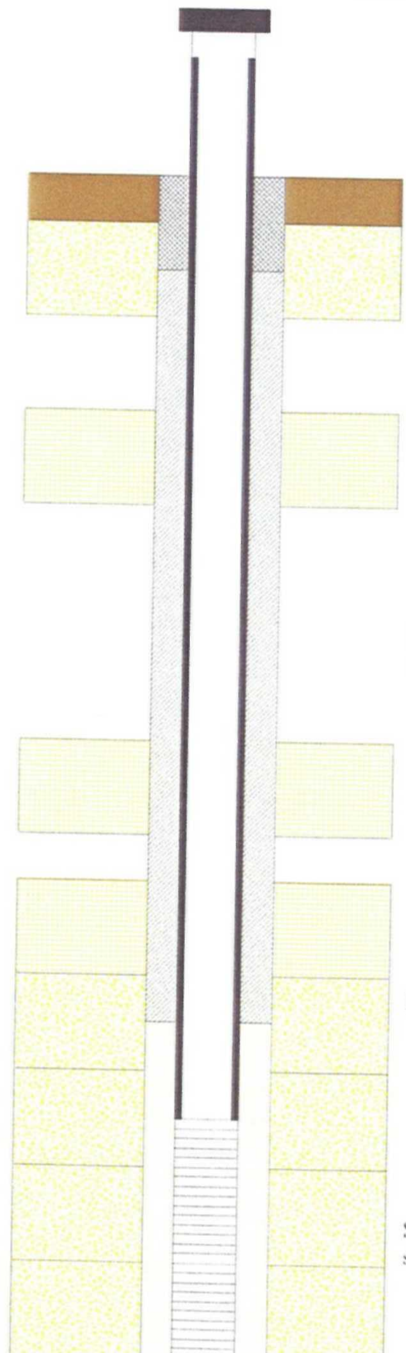


2009 LOGS

PROJECT: Area E Pre-Design Activities: Task C	E-MW6S
BORING LOCATION:	COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468117 NORTHERLY: 222838
DRILLING CONTRACTOR: ECDI: Ken Atwood	DATE STARTED: 10/6/09 DATE FINISHED: 10/6/09
DRILLING METHOD: HSA	TOTAL DEPTH (ft.): 25 MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Mobil B-57 Truck-Mounted Rotary Drill Rig	DEPTH TO WATER (Post Dev.)(ft): 16.72 GROUND SURFACE ELEVATION (NAVD 88): 56.96
SAMPLING METHOD: 2' Split-Spoon	LOGGED BY: Chris Lindahl TOP OF INNER CASING ELEVATION (NAVD 88): 59.77

Depth (feet)	Blow Counts	LITHOLOGY DESCRIPTION
0		Ground Surface
	N/A	0'-1' Topsoil
	N/A	1'-3' Light brown fine to medium SAND, little Silt, moist
	18-11-19-25	5'-7' 0-9": Dark brown fine SAND, trace Silt, trace coarse Gravel at bottom, dry, no odor/no staining; 9-18": Light brown fine SAND, trace Silt, dry, no odor/no staining
10		
	10-14-20-20	12'-14' Tannish brown fine SAND, trace Silt, trace fine Gravel, damp, no odor/no staining
	10-19-19-12	15'-17' Yellowish brown fine SAND, trace Silt, saturated
	10-19-19-12	17'-19' 0-4": Yellowish brown fine SAND, little Silt, saturated; 4-8": Light brown fine to medium SAND, some Silt, wet, no odor/no staining; 8-14": Yellowish brown fine to medium SAND, saturated, no odor/no staining
20	5-10-15-18	19'-21' 0-20": Yellowish brown fine to medium SAND, little Silt, saturated, no odor/no staining; 20-22": Yellowish brown fine SAND, little Silt, saturated, no odor/no staining
	4-5-8-9	21'-23' Yellowish brown fine to medium SAND, trace Silt, saturated, no odor/no staining
	8-5-4-3	23'-25' Yellowish brown fine to medium SAND, little Silt, saturated, no odor/no staining

WELL CONSTRUCTION DIAGRAM



REMARKS

Stickup Protector

Riser: 0-20 feet bgs w 2.5 foot stickup, 2-inch O PVC riser

Bentonite Cement Grout Seal: 2-18 feet bgs

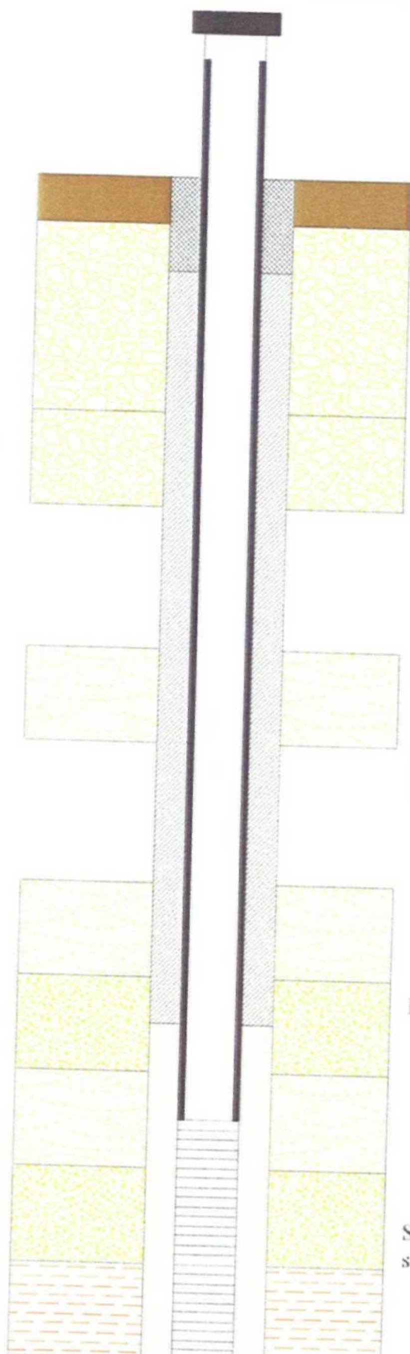
Filter Pack: 18-25 feet bgs, #0 size sand

Screened Interval: 20-25 feet, 0.010 slot, 2-inch O PVC screen

PROJECT: Area E Pre-Design Activities: Task E		E-MW7S	TRC
BORING LOCATION:		COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468538	NORTHERLY: 222348
DRILLING CONTRACTOR: ECDI: Wellington Reeve		DATE STARTED: 10/27/09	DATE FINISHED: 10/27/09
DRILLING METHOD: HSA		TOTAL DEPTH (ft.): 25	MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Mobil B-58 Truck-Mounted Rotary Drill Rig		DEPTH TO WATER (Post Dev.)(ft): 17.03	GROUND SURFACE ELEVATION (NAVD 88): 56
SAMPLING METHOD: 2' Split-Spoon		LOGGED BY: Mark Winbourne	TOP OF INNER CASING ELEVATION (NAVD 88): 58.29

Depth (feet)	Blow Counts	LITHOLOGY DESCRIPTION
0		Ground Surface
	N/A	0'-1' Topsoil
	N/A	1'-5' Light reddish brown fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist
	12-14-14-20	5'-7' Light reddish brown fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist
10	14-15-20-18	10'-12' Strong brown fine to coarse SAND, little Silt, moist
	10-9-9-9	15'-17' 0-12": Strong brown fine to coarse SAND, little Silt, moist; 12-18": Strong brown fine to coarse SAND, little Silt, wet
	6-5-4-4	17'-19' Strong brown, yellowish brown, and gray fine to medium SAND, trace Silt, wet
20	6-4-6-7	19'-21' Strong brown and yellowish brown fine to coarse SAND, some fine to coarse subrounded Gravel, wet
	4-5-5-6	21'-23' 0-10": Strong brown and gray fine to medium SAND, little Silt, wet; 10-16": Gray fine to medium SAND, some Silt, wet
	2-3-5-9	23'-25' 0-8": Gray SILT, some fine to medium Sand, wet; 8-14": Strong brown and gray fine to medium SAND, little Silt, wet

WELL CONSTRUCTION DIAGRAM



REMARKS

Stickup Protector

Riser: 0-20 feet bgs w 2.5 foot stickup. 2-inch O PVC riser

Bentonite Cement Grout Seal: 2-18 feet bgs

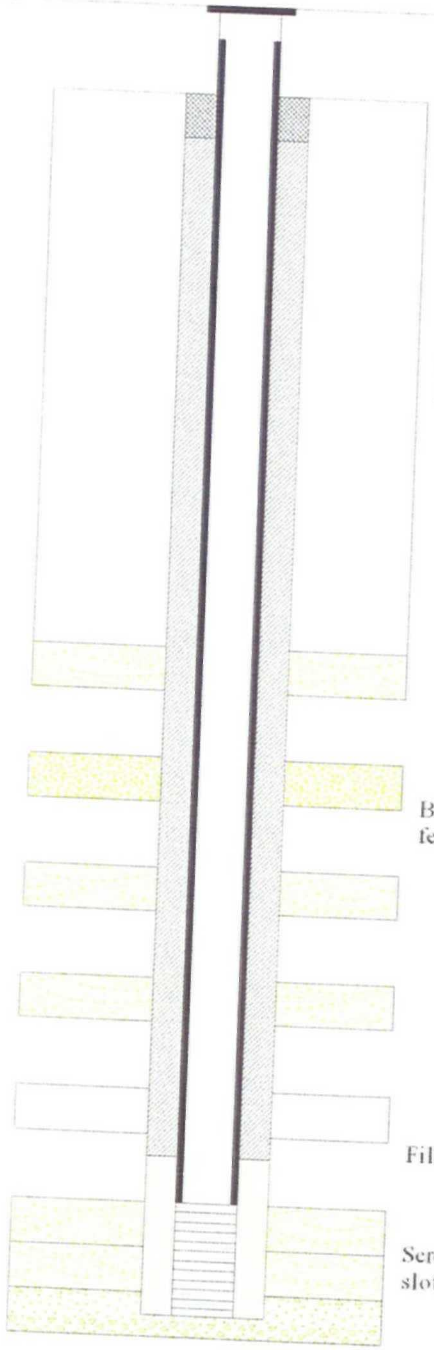
Filter Pack: 18-25 feet bgs. #0 size sand

Screened Interval: 20-25 feet. 0.010 slot. 2-inch O PVC screen

PROJECT: Area E Pre-Design Activities: Task E		E-MW7D	TRC
BORING LOCATION:		COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468555	NORTHERLY: 222353
DRILLING CONTRACTOR: ECDI: Wellington Reeve		DATE STARTED: 10/27/09	DATE FINISHED: 10/28/09
DRILLING METHOD: HSA		TOTAL DEPTH (ft.): 55	MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Mobil B-58 Truck-Mounted Rotary Drill Rig		DEPTH TO WATER (Post Dev.)(ft): 18.57	GROUND SURFACE ELEVATION (NAVD 88): 55.74
SAMPLING METHOD: 2' Split-Spoon		LOGGED BY: Mark Winbourne	TOP OF INNER CASING ELEVATION (NAVD 88): 58.19

Depth (feet)	Blow Counts	LITHOLOGY DESCRIPTION	REMARKS
0		0-0' Ground Surface	Stickup Protector
10		0-25' See E-MW7S Boring Log	Riser: 0-50 feet bgs w 2.5 foot stickup. 2-inch O PVC riser
20			
	11-11-11-11	25'-27' Strong brown and gray fine to coarse SAND, little Silt, wet	
30	25-50/3"	30'-32' Strong brown and brown fine to medium SAND, trace Silt, wet	Bentonite Cement Grout Seal: 2-48 feet bgs
	19-24-31-30	35'-37' Strong brown and gray fine to coarse SAND, little Silt, wet	
40	14-27-37-44	40'-42' Strong brown, yellowish brown, and gray fine to coarse SAND, trace fine subrounded Gravel, trace Silt, moist	
	N/A	45'-47' Not Sampled: 5 feet of Sand in Hollow Stem Upon Inserting Split Spoon	Filter Pack: 48-55 feet bgs, #0 size sand
50	12-15-22-24	50'-52' Light reddish brown, yellowish brown, and gray fine to coarse SAND, trace Silt, wet	
	20-23-23-22	52'-54' Yellowish brown fine to coarse SAND, trace fine subrounded Gravel, trace Silt, wet	Screened Interval: 50-55 feet, 0.010 slot, 2-inch O PVC screen
	15-19-26-35	54'-56' Yellowish brown fine to coarse GRAVEL, little fine to coarse SAND, little Silt, wet	
60			

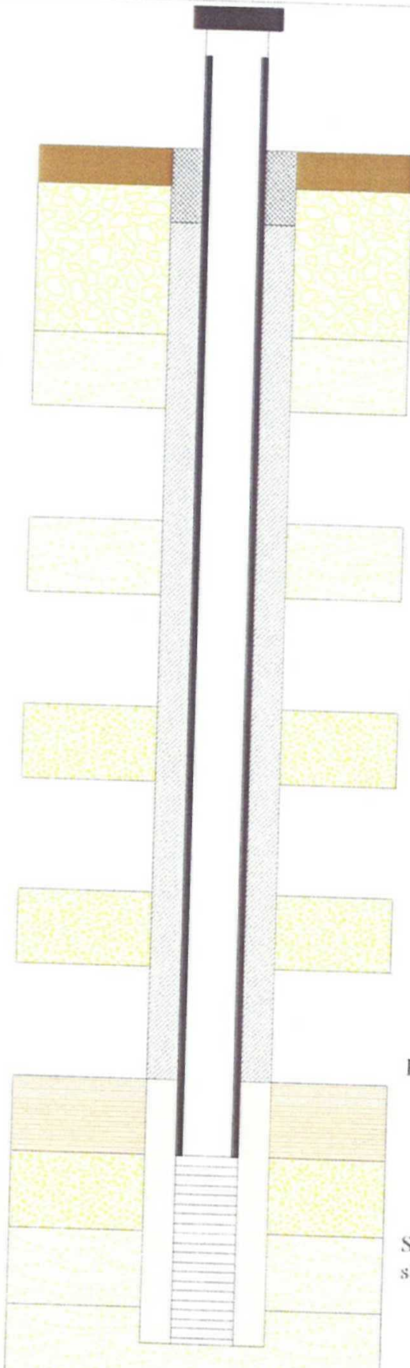
WELL CONSTRUCTION DIAGRAM



PROJECT:			
Area E Pre-Design Activities: Task E	E-MW8S		TRC
BORING LOCATION:	COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468514	NORTHERLY: 222559	
DRILLING CONTRACTOR: ECDI: Wellington Reeve	DATE STARTED: 10/26/09	DATE FINISHED: 10/26/09	
DRILLING METHOD: HSA	TOTAL DEPTH (ft.): 32	MEASURING POINT: Ground Surface	
DRILLING EQUIPMENT: Mobil B-58 Truck-Mounted Rotary Drill Rig	DEPTH TO WATER (Post Dev.)(ft): 21.65	GROUND SURFACE ELEVATION (NAVD 88): 59.13	
SAMPLING METHOD: 2' Split-Spoon	LOGGED BY: Mark Winbourne	TOP OF INNER CASING ELEVATION (NAVD 88): 60.86	

Depth (feet)	Blow Counts	LITHOLOGY DESCRIPTION	REMARKS
			Stickup Protector
0	N/A	Ground Surface 0'-1' Topsoil	
	N/A	1'-5' Brown fine to coarse SAND and fine to coarse subrounded GRAVEL, little Silt, moist medium dense	
	12-16-15-11	5'-7' Strong brown fine to coarse SAND, little Silt, little fine subrounded Gravel, moist	Riser: 0-27 feet bgs w/2.5 foot stickup, 2-inch O PVC riser
10	7-8-12-11	10'-12' Light yellowish brown fine to coarse SAND, trace Silt, moist	
	4-7-11-14	15'-17' 0-8": Yellowish brown fine to medium SAND, trace fine subrounded Gravel, moist, 8-14": Yellowish brown fine to medium SAND, trace fine subrounded Gravel, wet	Bentonite Cement Grout Seal: 2-25 feet bgs
20	2-5-6-9	20'-22' 0-6": Yellowish brown and gray-mottled fine to medium SAND, some Silt, moist; 6-18": Yellowish brown and gray-mottled fine to medium SAND, some Silt, wet	
	Wr/12"-6-10	25'-27' 0-15": Dark reddish brown, yellow, and gray-mottled SILT and CLAY, moist, 15-20": Strong brown and gray-mottled fine to medium SAND, little Silt, wet	Filter Pack: 25-32 feet bgs, #0 size sand
	8-11-11-12	27'-29' Strong brown and gray fine to medium SAND, little Silt, wet	
30	7-8-22-40	29'-31' Yellowish brown, strong brown, and red fine to coarse SAND, little Silt, wet	Screened Interval: 27-32 feet, 0.010 slot, 2-inch O PVC screen
	4-5-9-9	31'-33' Yellowish brown fine to coarse SAND, little Silt, wet	

WELL CONSTRUCTION DIAGRAM

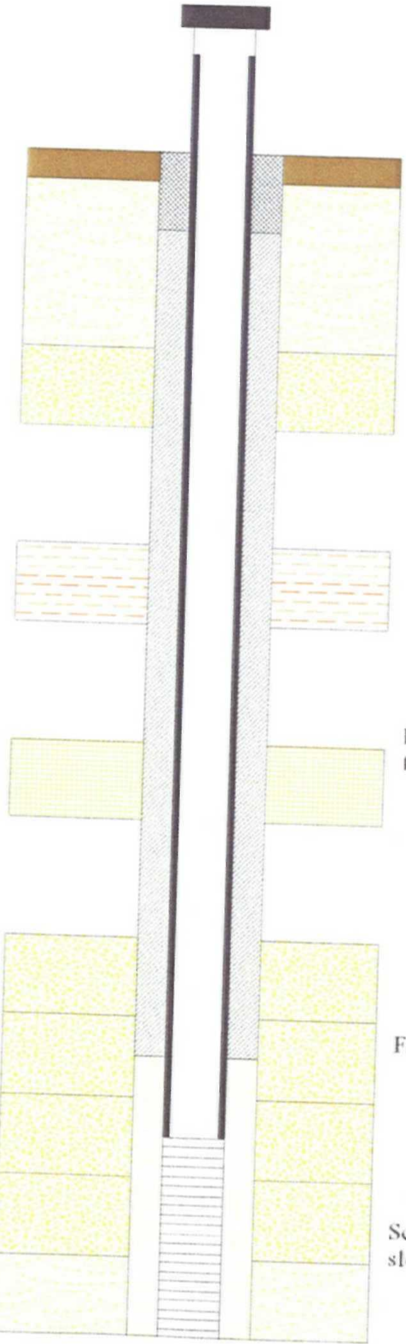


PROJECT: Area E Pre-Design Activities: Task E	E-MW9S	TRC

BORING LOCATION:		COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468719	NORTHERLY: 222585
DRILLING CONTRACTOR: ECDI: Wellington Reeve		DATE STARTED: 10/28/09	DATE FINISHED: 10/29/09
DRILLING METHOD: HSA		TOTAL DEPTH (ft.): 30	MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Mobil B-58 Truck-Mounted Rotary Drill Rig		DEPTH TO WATER (Post Dev.)(ft): 22.8	GROUND SURFACE ELEVATION (NAVD 88): 59.04
SAMPLING METHOD: 2' Split-Spoon		LOGGED BY: Mark Winbourne	TOP OF INNER CASING ELEVATION (NAVD 88): 60.3

Depth (feet)	Blow Counts	LITHOLOGY DESCRIPTION
0	N/A	Ground Surface 0'-0.75' Topsoil
	N/A	0.75'-5' Strong brown fine to coarse SAND, some fine to coarse subrounded Gravel, trace Silt, moist
	6-9-14-19	5-7' Strong brown fine to medium SAND, little Silt, moist
10	6-7-7-9	10'-12' 0-4": Strong brown fine to medium SAND, little Silt, moist; 4-16": Strong brown and gray SILT, some CLAY, trace fine Sand, moist
	10-17-19-18	15'-17' Strong brown fine SAND, some coarse subrounded Gravel, trace Silt, moist
20	4-7-9-12	Strong brown and gray-mottled fine to medium SAND, some Silt, wet
	5-9-10-11	22'-24' Strong brown and gray-mottled fine to medium SAND, some Silt, wet
	6-10-9-14	24'-26' Strong brown and gray-mottled fine to medium SAND, some Silt, wet
	5-10-12-11	26'-28' Strong brown and gray-mottled fine to medium SAND, some Silt, wet
30	2-5-9-11	28'-30' Strong brown and gray fine to coarse SAND, little Silt, wet

WELL CONSTRUCTION DIAGRAM



REMARKS

Stickup Protector

Riser: 0-25 feet bgs w/ 1 foot stickup. 2-inch O PVC riser

Bentonite Cement Grout Seal: 2-23 feet bgs

Filter Pack: 23-30 feet bgs. #0 size sand

Screened Interval: 25-30 feet. 0.010 slot. 2-inch O PVC screen

PROJECT: Area E Pre-Design Activities: Task D	E-B9	TRC
BORING LOCATION: at E-S21	COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468371 NORTHERLY: 222681	
DRILLING CONTRACTOR: ECDI: Jim Zigger	DATE STARTED: 10/12/09	DATE FINISHED: 10/12/09
DRILLING METHOD: Directpush	TOTAL DEPTH (ft.): 20	MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Geoprobe 5400	DEPTH TO WATER: 18	GROUND SURFACE ELEVATION (NAVD88)
SAMPLING METHOD: 5' Macrocore	LOGGED BY: Mark Winbourne	
HAMMER WEIGHT: N/A DROP: N/A	RESPONSIBLE PROFESSIONAL: Larry Butlien	

Depth (feet)	Recovery (feet)	Penetration (feet)	Recovery %	PID (ppm)	Sample Interval	Lithology Symbol	DESCRIPTION
0-5	4	5	80%				0'-5' 0-8": Topsoil; 8-16": Strong brown fine to medium SAND and SILT, little Gravel; 16-48": Yellowish brown fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist
5-10	3.3	5	66%				5'-10' 0-20": Strong brown fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist; 20-40": Light yellowish brown fine to coarse SAND, trace Silt, moist, w discrete 1" thick wet zones from 30-36"
10-15	2.5	5	50%		E-B9(12.5-15)		10'-15' 0-10": Light gray fine to medium SAND; 10-30": Strong brown, brown and light gray fine to coarse SAND, trace Silt, interlayered (range from 1 8-1 2" thick)
15-20	4.8	5	96%		E-B9(15-17.5)		15'-20' 0-18": Strong brown, brown and light gray fine to coarse SAND, trace Silt, interlayered (range from 1 8-1 2" thick); 18-36": White fine to medium SAND, moist; 36-58": White fine to medium SAND, wet

PROJECT: Area E Pre-Design Activities: Task D	E-B10 TRC
BORING LOCATION: at E-S24	COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468284 NORTHERLY: 222624
DRILLING CONTRACTOR: ECDI: Jim Zigger	DATE STARTED: 10/12/09 — DATE FINISHED: 10/12/09
DRILLING METHOD: Directpush	TOTAL DEPTH (ft.): 20 — MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Geoprobe 5400	DEPTH TO WATER: 17 — GROUND SURFACE ELEVATION (NAVD88):
SAMPLING METHOD: 5' Macrocore	LOGGED BY: Mark Winbourne
HAMMER WEIGHT: N/A — DROP: N/A	RESPONSIBLE PROFESSIONAL: Larry Butlien

Depth (feet)	Recovery (feet)	Penetration (feet)	Recovery %	PID (ppm)	Sample Interval	Lithology Symbol	DESCRIPTION
0-5	3.3	5	66%				0'-5' 0-8": Topsoil; 8-20": Brown fine to medium SAND and SILT, moist; 20-40": Yellowish brown and white fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist
5-10	3.2	5	64%				5'-10' 0-24": Yellowish brown and white fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist; 24-38": Strong brown and yellowish brown fine to coarse SAND, trace fine subrounded Gravel, trace Silt, moist, w/ a wet seam from 26-36"
10-15	3.7	5	74%		E-B10(12.5-15)		10'-15' 0-8": Strong brown and yellowish brown fine to coarse SAND, trace fine subrounded Gravel, trace Silt, moist; 8-18": Dark gray fine to coarse SAND, SILT, and fine to coarse subrounded GRAVEL, moist; 18-30": Strong brown fine to coarse SAND, moist; 30-44": Light gray fine to coarse SAND, trace Silt, moist
15-20	3.3	5	66%		E-B10(15-17.5)		15'-20' 0-8": Strong brown and light gray fine to coarse SAND, trace Silt, moist; 8-11": Dark gray fine to medium SAND and SILT, moist; 11-26": Strong brown and light gray fine to coarse SAND, moist; 26-40": Strong brown and light gray fine to coarse SAND, wet

PROJECT: Area E Pre-Design Activities: Task D	E-B11
BORING LOCATION: at E-S5	COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468427 NORTHERLY: 222555
DRILLING CONTRACTOR: ECDI: Jim Zigger	DATE STARTED: 10/12/09 DATE FINISHED: 10/12/09
DRILLING METHOD: Directpush	TOTAL DEPTH (ft.): 20 MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Geoprobe 5400	DEPTH TO WATER: 16 GROUND SURFACE ELEVATION (NAVD88):
SAMPLING METHOD: 5' Macrocore	LOGGED BY: Mark Winbourne
HAMMER WEIGHT: N/A DROP: N/A	RESPONSIBLE PROFESSIONAL: Larry Butlien

Depth (feet)	Recovery (feet)	Penetration (feet)	Recovery %	PID (ppm)	Sample Interval	Lithology Symbol	DESCRIPTION
0–5	3.7	5	74%				0'-5' 0-10": Topsoil; 10-24": Strong brown fine to coarse SAND, SILT, and fine to coarse subrounded GRAVEL, moist; 24-44": White and gray fine to coarse SAND and fine to coarse subrounded GRAVEL, moist
5–10	3.2	5	64%				5'-10' 0-16": White and gray fine to coarse SAND and fine to coarse subrounded GRAVEL, moist; 16-38": Strong brown and yellowish brown fine to medium SAND and SILT, moist, interlayered(layers range from 1 16-1 2" thick)
10–15	3.7	5	74%		E-B11(12.5-15)		10'-15' 0-10": Strong brown and yellowish brown fine to medium SAND and SILT, moist, interlayered(layers range from 1 16-1 2" thick); 10-16": Dark gray fine to medium SAND and SILT, moist; 16-44": Strong brown and light gray fine to coarse SAND, trace Silt
15–20	4.2	5	84%		E-B11(15-17.5)		15'-20' 0-16": Gray fine to coarse SAND, some fine to coarse subrounded Gravel, trace Silt, moist; 16-50": Strong brown and yellowish brown fine to coarse SAND, trace Silt, wet (interlayered, layers range from 1 16-1" thick)

PROJECT: Area E Pre-Design Activities: Task D	E-B12 TRC
BORING LOCATION: at E-S6	COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468420 NORTHERLY: 222539
DRILLING CONTRACTOR: ECDI: Jim Zigger	DATE STARTED: 10/12/09 / DATE FINISHED: 10/12/09
DRILLING METHOD: Directpush	TOTAL DEPTH (ft.): 20 / MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Geoprobe 5400	DEPTH TO WATER: 16 / GROUND SURFACE ELEVATION (NAVD88)
SAMPLING METHOD: 5' Macrocore	LOGGED BY: Mark Winbourne
HAMMER WEIGHT: N/A / DROP: N/A	RESPONSIBLE PROFESSIONAL: Larry Butlien

Depth (feet)	Recovery (feet)	Penetration (feet)	Recovery %	PID (ppm)	Sample Interval	Lithology Symbol	DESCRIPTION
0-5	3.7	5	74%				0'-5' 0-8": Topsoil; 8-30": Strong brown fine to coarse SAND, SILT, and fine to coarse subrounded GRAVEL, moist; 30-44": Strong brown and gray fine to coarse SAND, SILT, and fine to coarse GRAVEL, moist
5-10	3	5	60%				5'-10' Strong brown and gray fine to coarse SAND, SILT, and fine to coarse GRAVEL, moist
10-15	3.8	5	76%		E-B12(10-12.5) E-B12(12.5-15)		10'-15' 0-6": Strong brown and gray fine to coarse SAND, SILT, and fine to coarse GRAVEL, moist; 6-15": Dark brown fine to coarse SAND, SILT, and fine to coarse subrounded GRAVEL, moist; 15-46": Yellowish brown and light gray fine to coarse SAND, trace fine Gravel, trace Silt, moist, w wet seam from 21-33"
15-20	3.7	5	74%		E-B12(15-17.5)		15'-20' 0-10": Yellowish brown and light gray fine to coarse SAND, trace fine Gravel, trace Silt, moist; 10-45": Yellowish brown and light gray fine to coarse SAND, trace fine Gravel, trace Silt, wet

PROJECT: Area E Pre-Design Activities: Task D

E-B13

TRC

BORING LOCATION: Approx. midway btwn. E-S22 and E-S23	COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468342 NORTHERLY: 222645
DRILLING CONTRACTOR: ECDI: Jim Zigger	DATE STARTED: 10/12/09 / DATE FINISHED: 10/12/09
DRILLING METHOD: Directpush	TOTAL DEPTH (ft.): 20 / MEASURING POINT: Ground Surface
DRILLING EQUIPMENT: Geoprobe 5400	DEPTH TO WATER: 17 / GROUND SURFACE ELEVATION (NAVD88):
SAMPLING METHOD: 5' Macrocore	LOGGED BY: Mark Winbourne
HAMMER WEIGHT: N/A / DROP: N/A	RESPONSIBLE PROFESSIONAL: Larry Butlien

Depth (feet)	Recovery (feet)	Penetration (feet)	Recovery %	PID (ppm)	Sample Interval	Lithology Symbol	DESCRIPTION
0-5	4.2	5	84%				0'-5' 0-8": Topsoil; 8-16": Brown fine to medium SAND and SILT, moist; 16-40": Reddish brown fine to medium SAND, SILT, and fine to coarse subrounded GRAVEL, moist; 40-50": Strong brown and light gray fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist
5-10	3.7	5	74%				5'-10' 0-24": Strong brown and light gray fine to coarse SAND and fine to coarse subrounded GRAVEL, trace Silt, moist; 24-44": Strong brown and yellowish brown fine to coarse SAND, little Silt, moist, wet seam from 30-38"
10-15	3.8	5	76%		E-B13(12.5-15)		10'-15' 0-16": Strong brown, yellowish brown, and gray fine to coarse SAND, little Silt, moist; 16-46": Light yellowish brown and light gray fine to coarse SAND, trace Silt, moist
15-20	3.2	5	64%		E-B13(15-17.5)		15'-20' 0-10": Strong brown and brown fine to coarse SAND, SILT, and fine subrounded GRAVEL, moist; 10-20": Yellowish brown and strong brown fine to coarse SAND, trace Silt, moist; 20-39": Yellowish brown and strong brown fine to coarse SAND, trace Silt, wet

PROJECT: Area E Pre-Design Activities: Task D

E-B14

TRC

BORING LOCATION: Approx. midway btwn. E-GP20 and E-GP25

COORDINATES (NJ PLANE SYSTEM - NAD83) EASTERLY: 468529 NORTHERLY: 222381

DRILLING CONTRACTOR: ECDI: Jim Zigger

DATE STARTED: 10/12/09

DATE FINISHED: 10/12/09

DRILLING METHOD: Directpush

TOTAL DEPTH (ft.): 15

MEASURING POINT: Ground Surface

DRILLING EQUIPMENT: Geoprobe 5400

DEPTH TO WATER: 12

GROUND SURFACE ELEVATION (NAVD88):

SAMPLING METHOD: 5' Macrocore

LOGGED BY: Mark Winbourne

HAMMER WEIGHT: N/A

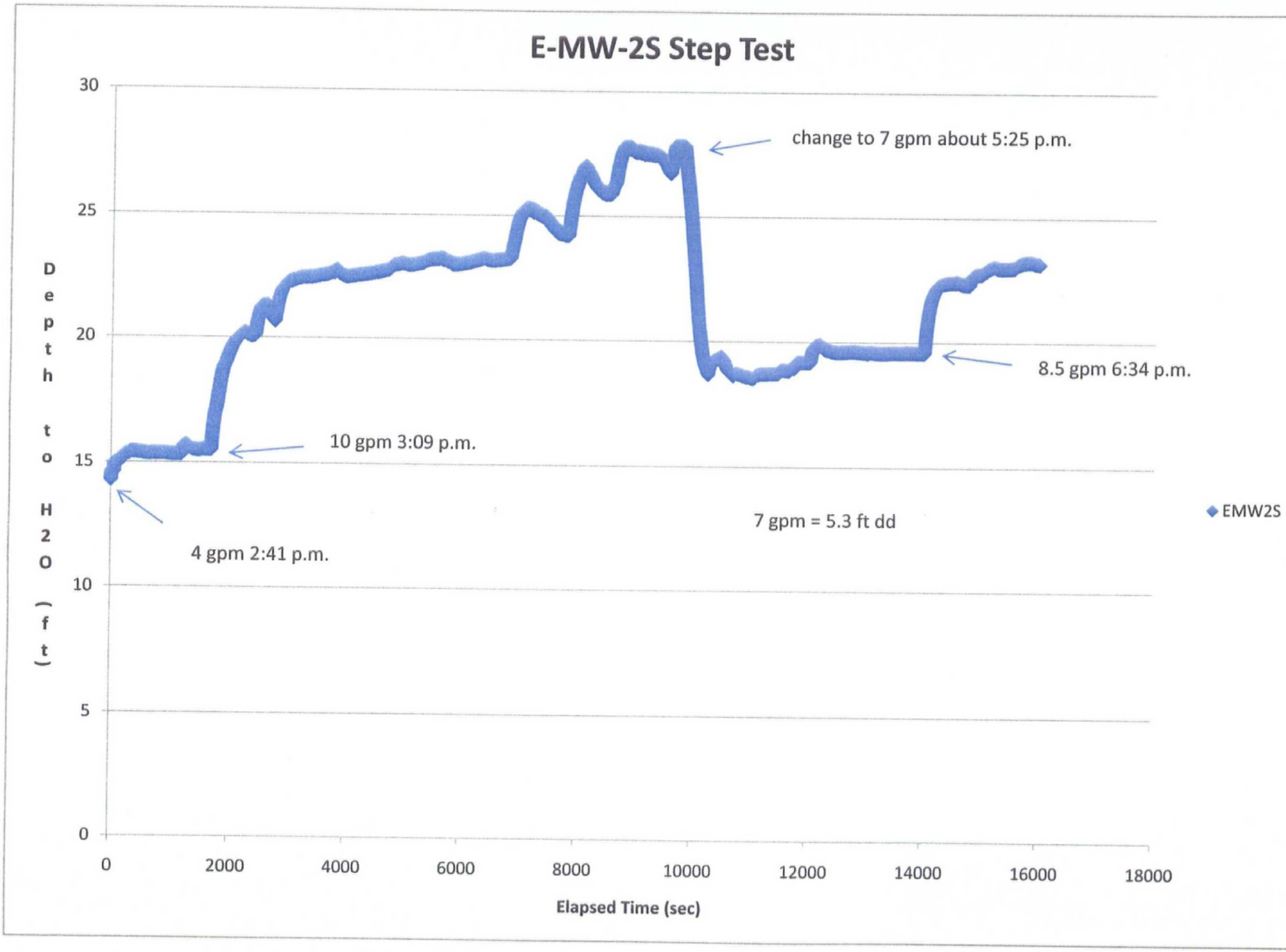
DROP: N/A

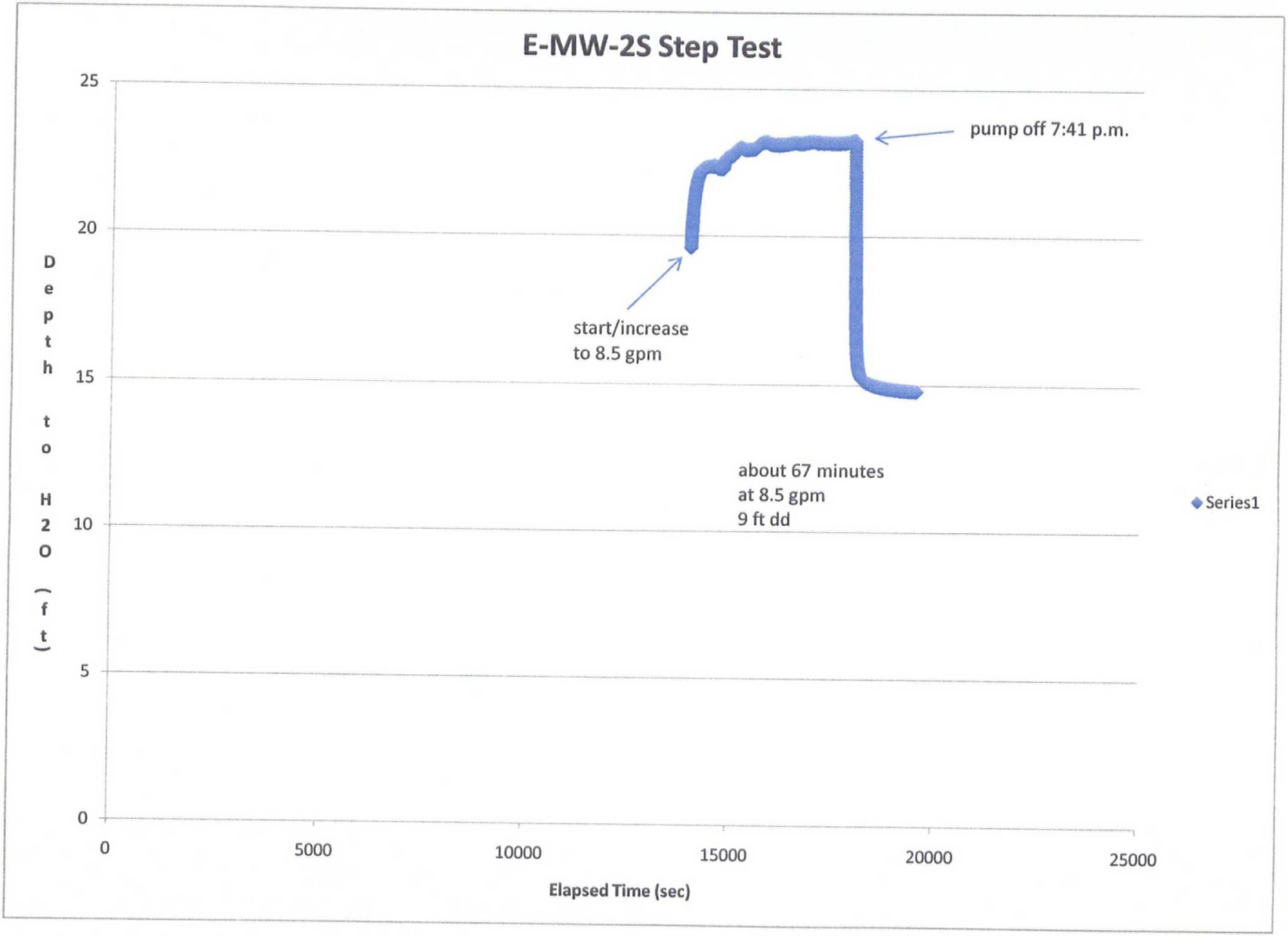
RESPONSIBLE PROFESSIONAL: Larry Butlien

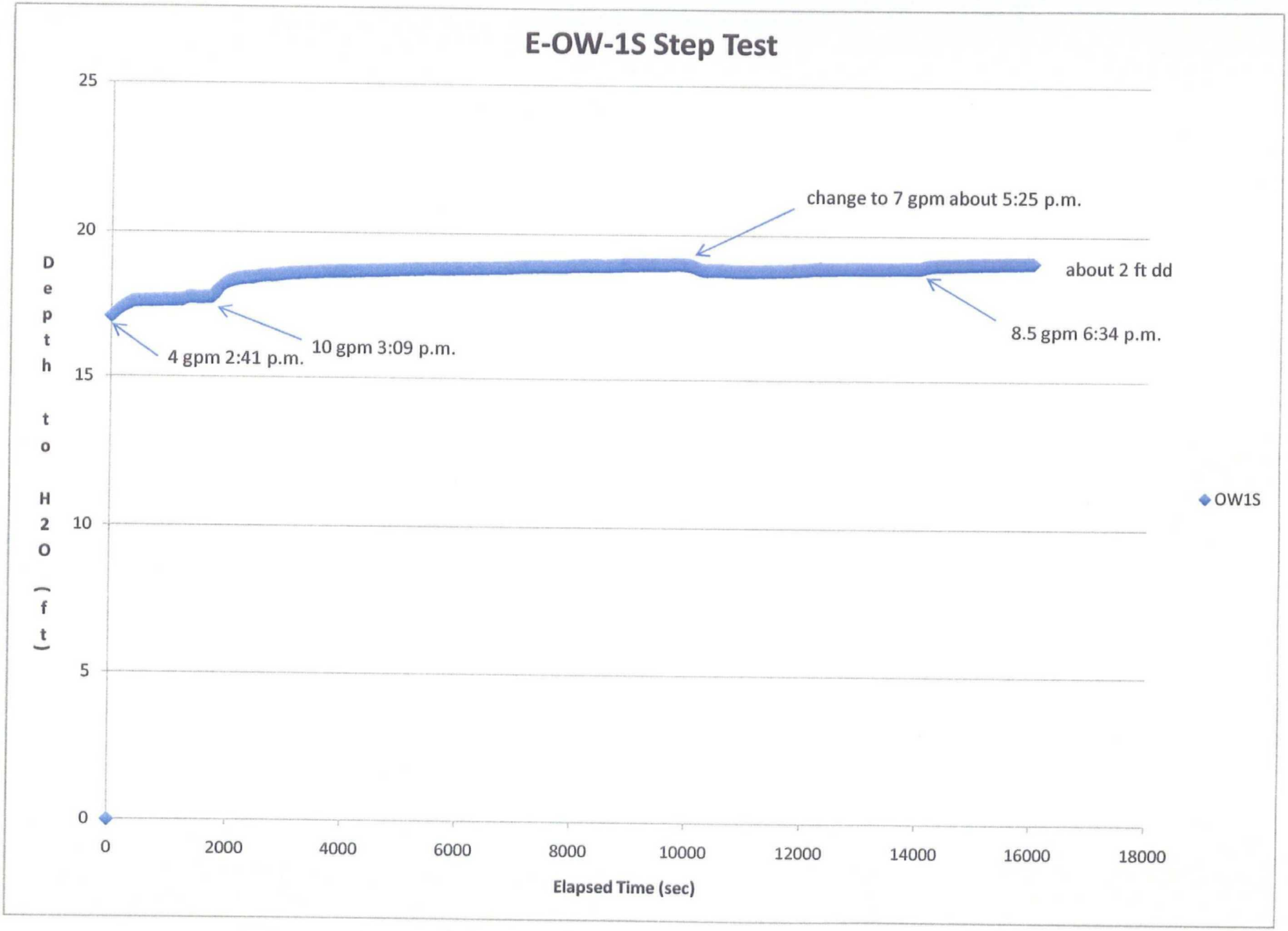
Depth (feet)	Recovery (feet)	Penetration (feet)	Recovery %	PID (ppm)	Sample Interval	Lithology Symbol	DESCRIPTION
0–5	2.7	5	54%				0'-5' 0-12": Topsoil; 12-32": Brown fine to coarse SAND, SILT, and fine to coarse subrounded GRAVEL, moist
5–10	2.8	5	56%		E-B14(7.5-10)		5'-10' Strong brown fine to medium SAND, some Silt, trace fine to coarse subrounded Gravel, moist
10–15	2.7	5	54%		E-B14(10-12.5)		10'-15' 0-18": Light brown and light yellowish brown fine to medium SAND, little Silt, moist; 18-32": Light brown, light yellowish brown, and strong brown fine to medium SAND, little Silt, wet

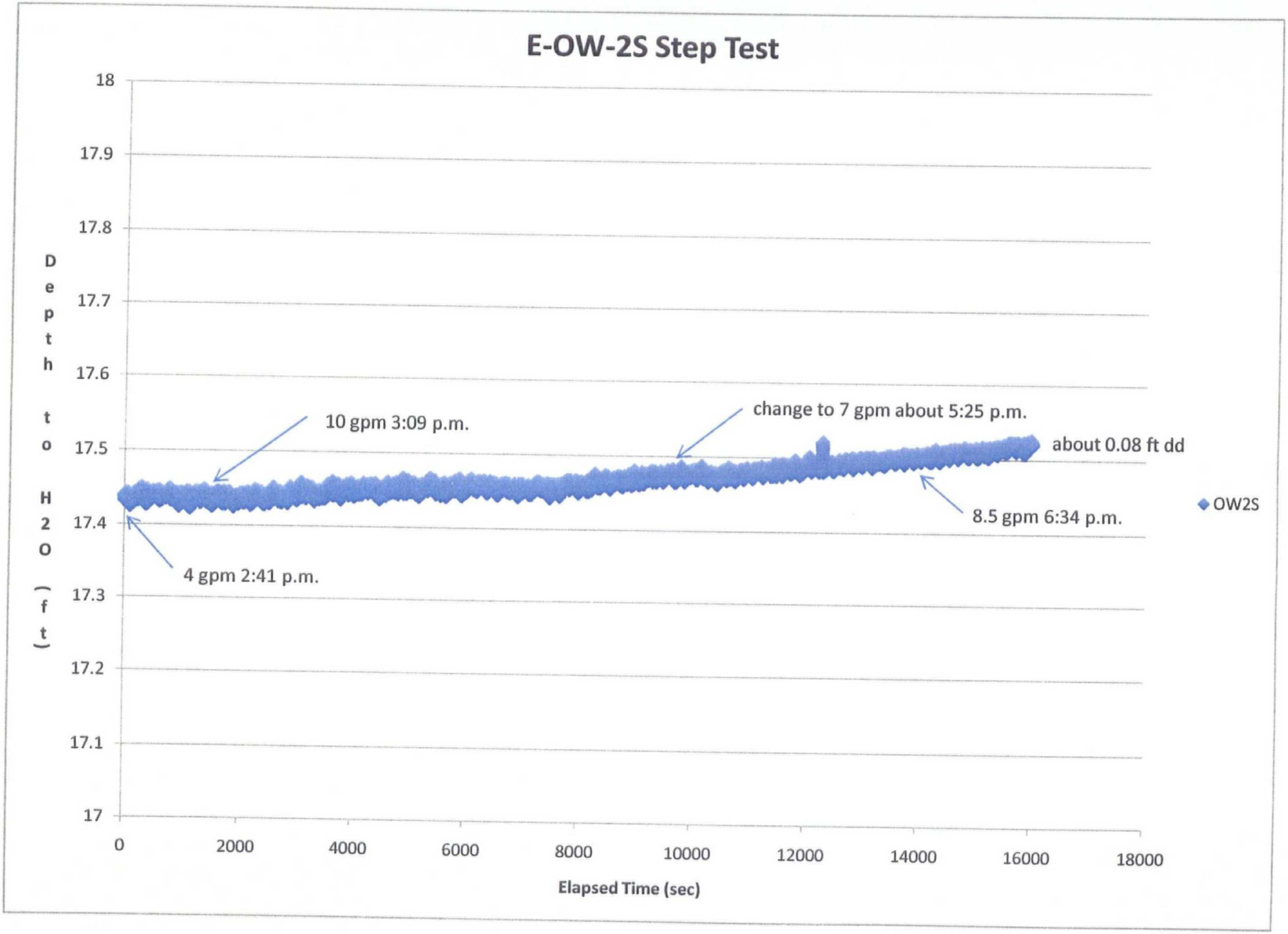
APPENDIX B

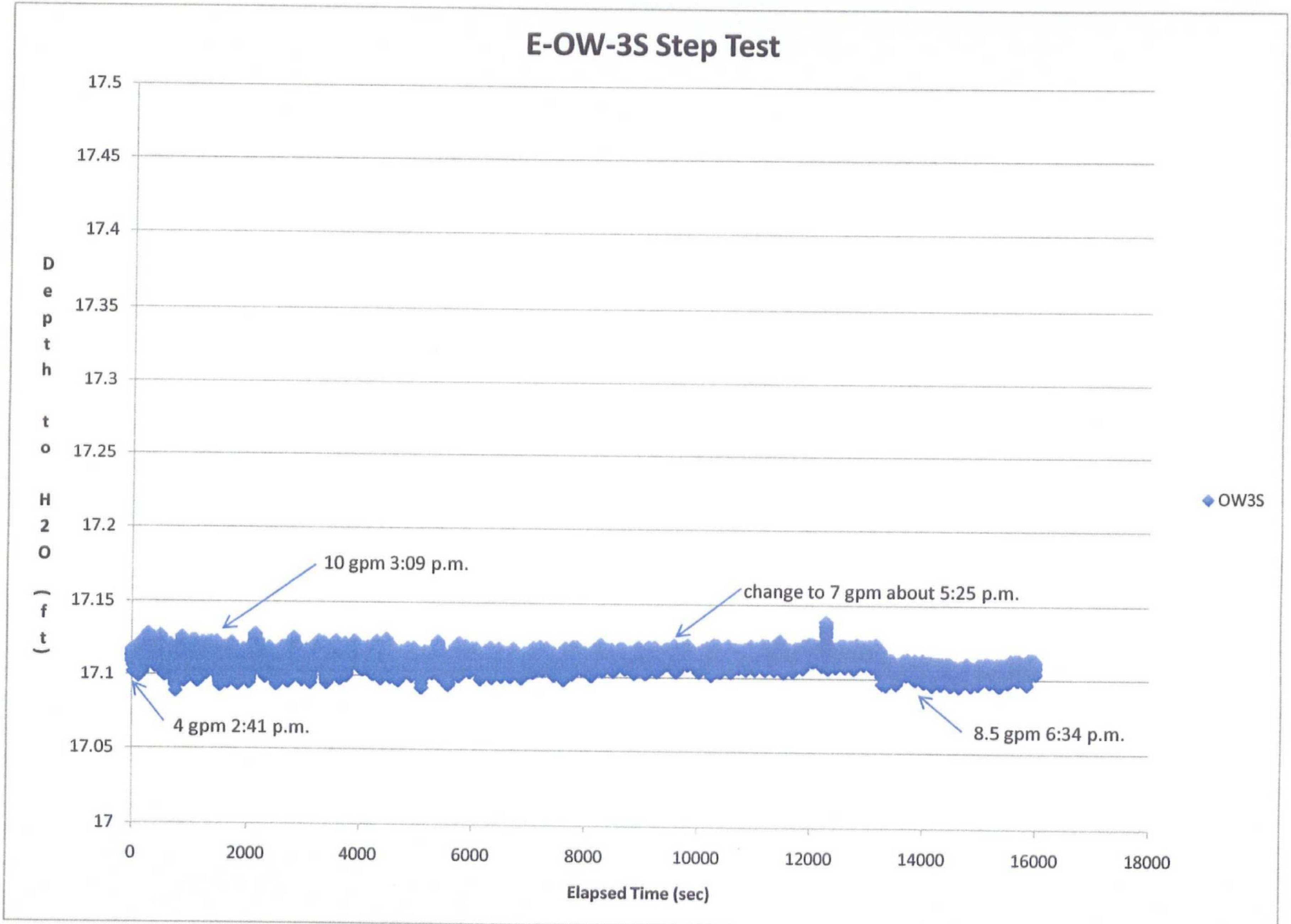
STEP-DRAWDOWN TEST PLOTS


E-MW-2S Step Test
change to 7 gpm about 5:25 p.m.
8.5 gpm 6:34 p.m.
10 gpm 3:09 p.m.
4 gpm 2:41 p.m.
7 gpm = 5.3 ft dd
EMW2S
Depth to H2O (ft)
Elapsed Time (sec)
0
5
10
15
20
25
30
0
2000
4000
6000
8000
10000
12000
14000
16000
18000


E-MW-2S Step Test
25
20
15
10
5
0
Depth to H2O (ft)
0
5000
10000
15000
20000
25000
Elapsed Time (sec)
pump off 7:41 p.m.
start/increase
to 8.5 gpm
about 67 minutes
at 8.5 gpm
9 ft dd
Series1

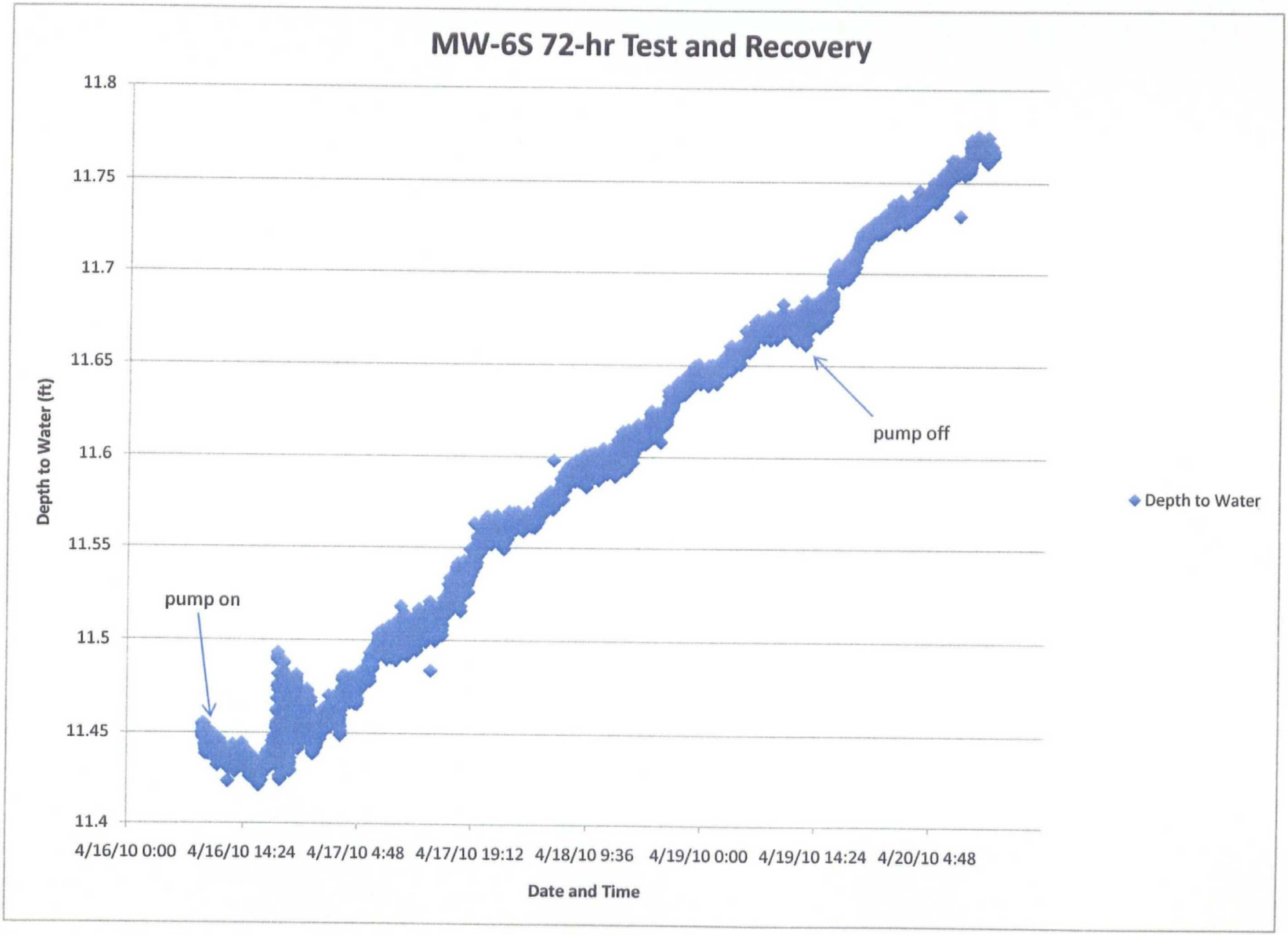

E-OW-1S Step Test
Depth to H2O (ft)
25
20
15
10
5
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Elapsed Time (sec)
change to 7 gpm about 5:25 p.m.
about 2 ft dd
4 gpm 2:41 p.m.
10 gpm 3:09 p.m.
8.5 gpm 6:34 p.m.
OW1S

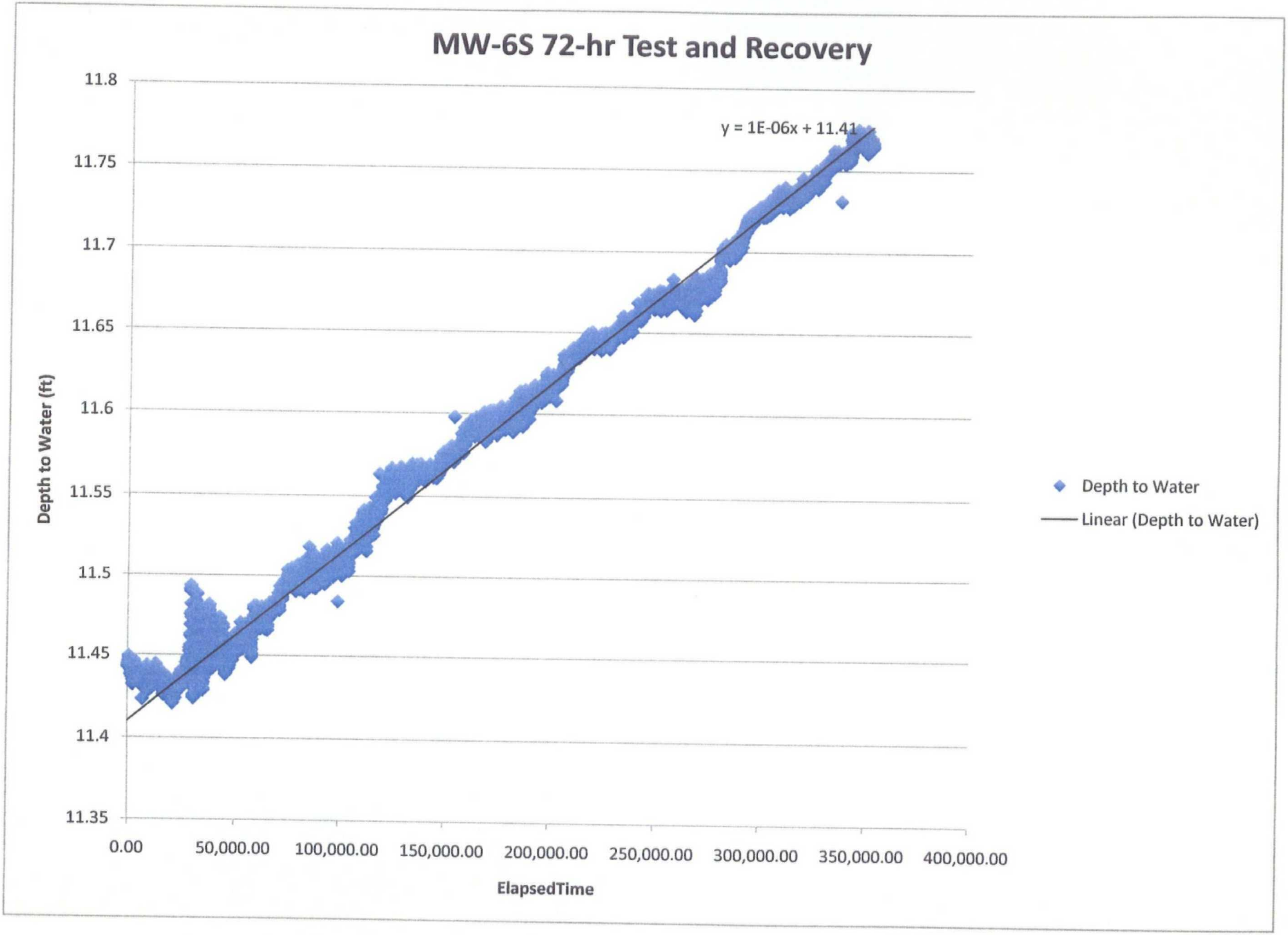

E-OW-2S Step Test
18
17.9
17.8
17.7
17.6
17.5
17.4
17.3
17.2
17.1
17
Depth to H2O (ft)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Elapsed Time (sec)
10 gpm 3:09 p.m.
change to 7 gpm about 5:25 p.m.
about 0.08 ft dd
8.5 gpm 6:34 p.m.
4 gpm 2:41 p.m.
OW2S


E-OW-3S Step Test
17.5
17.45
17.4
17.35
17.3
17.25
17.2
17.15
17.1
17.05
17
Depth to H2O (ft)
10 gpm 3:09 p.m.
change to 7 gpm about 5:25 p.m.
4 gpm 2:41 p.m.
8.5 gpm 6:34 p.m.
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Elapsed Time (sec)
OW3S

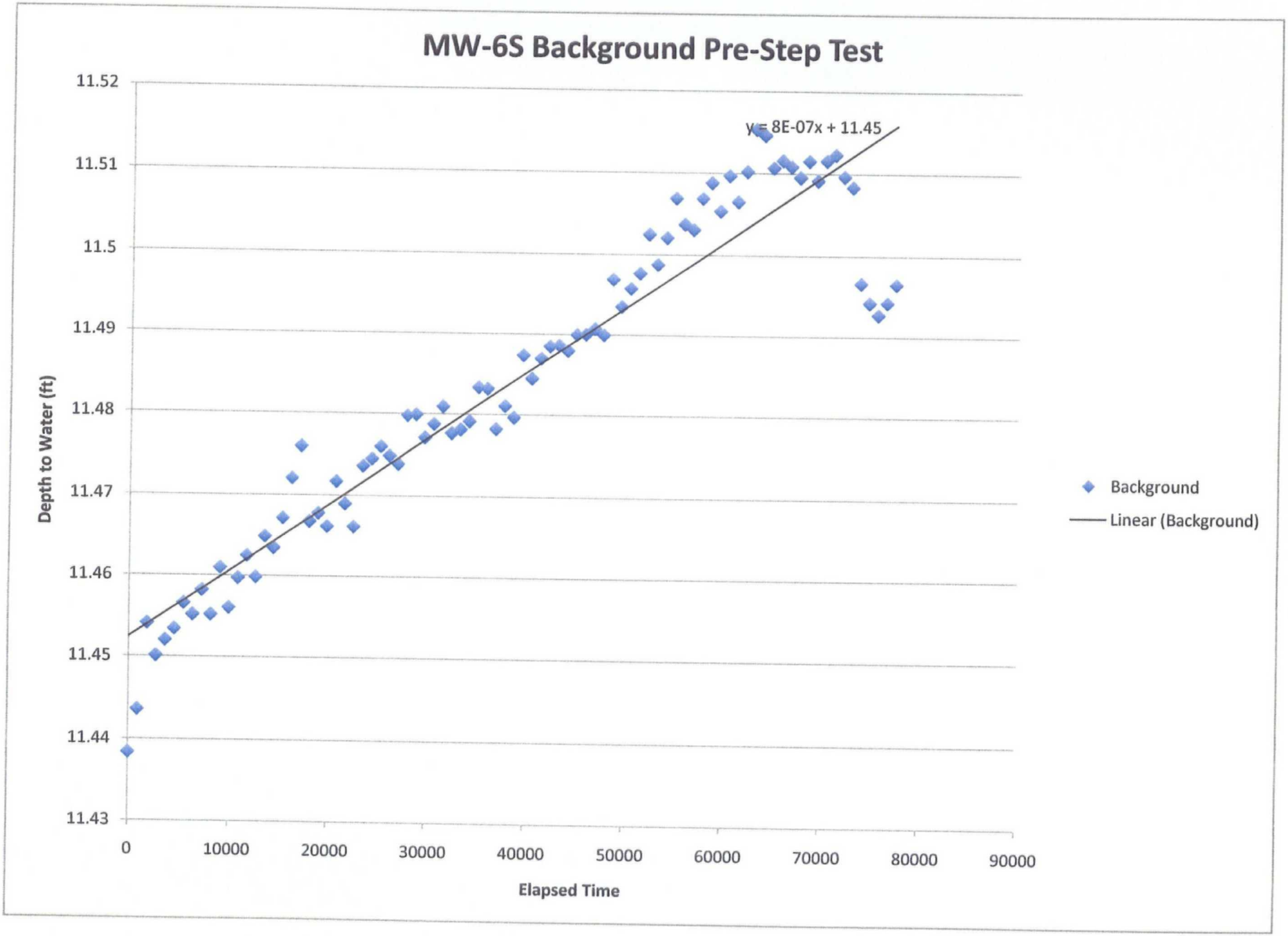
APPENDIX C

E-MW6S BACKGROUND WATER LEVELS


MW-6S 72-hr Test and Recovery
Depth to Water (ft)
11.8
11.75
11.7
11.65
11.6
11.55
11.5
11.45
11.4
pump on
pump off
4/16/10 0:00
4/16/10 14:24
4/17/10 4:48
4/17/10 19:12
4/18/10 9:36
4/19/10 0:00
4/19/10 14:24
4/20/10 4:48
Date and Time
Depth to Water

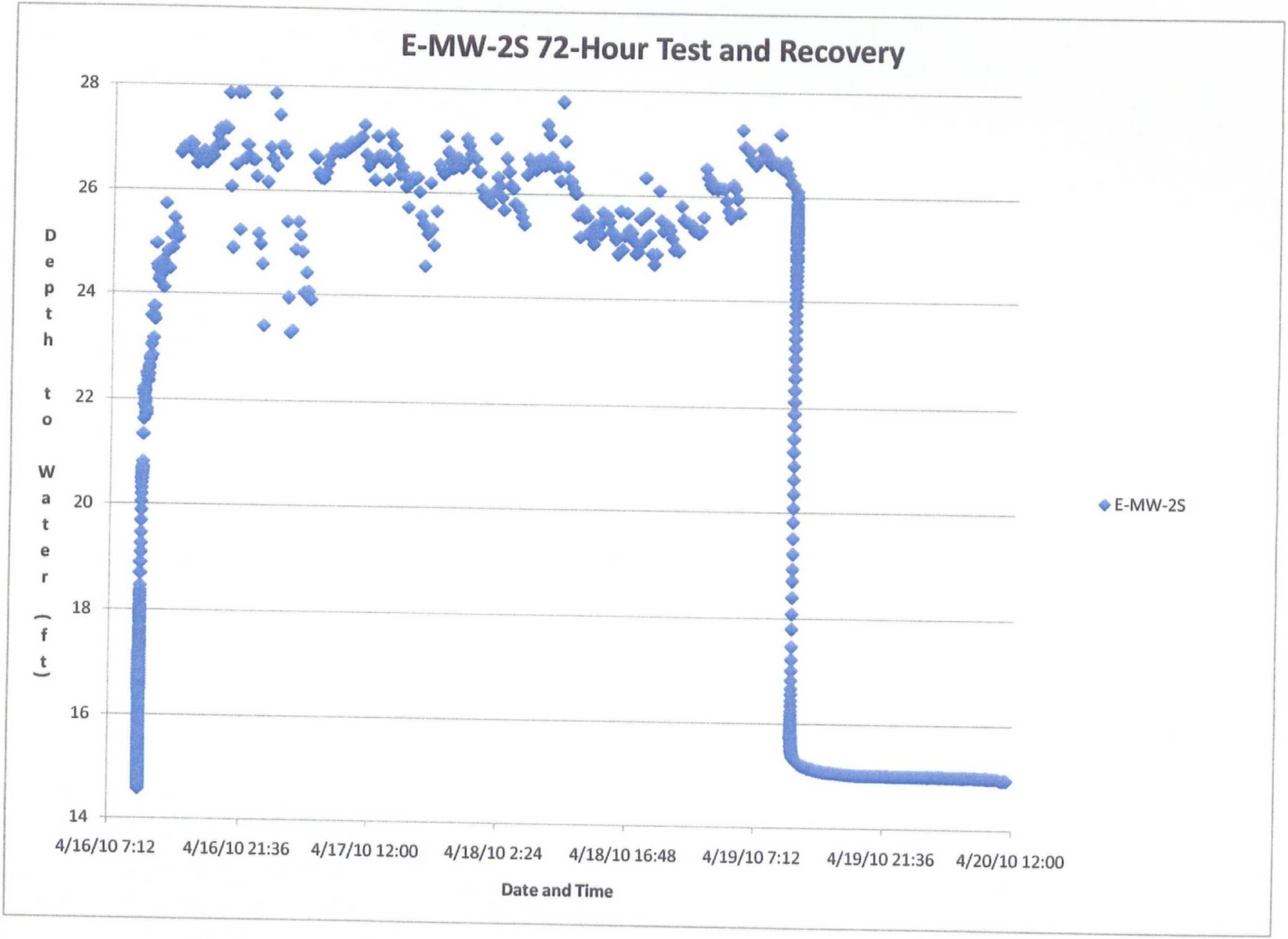


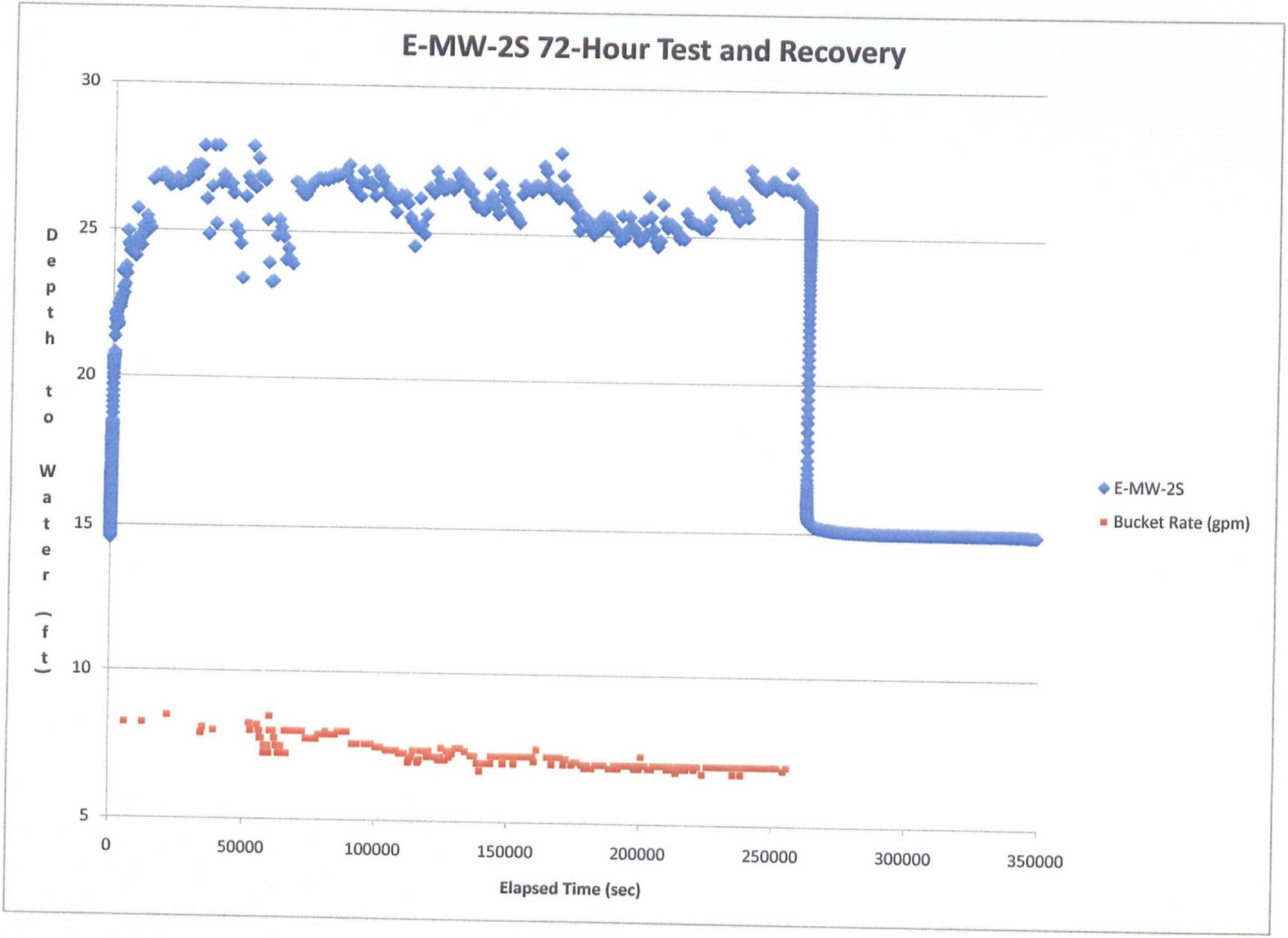
MW-6S 72-hr Test and Recovery
y = 1E-06x + 11.41
Depth to Water (ft)
11.8
11.75
11.7
11.65
11.6
11.55
11.5
11.45
11.4
11.35
0.00
50,000.00
100,000.00
150,000.00
200,000.00
250,000.00
300,000.00
350,000.00
400,000.00
ElapsedTime
Depth to Water
Linear (Depth to Water)

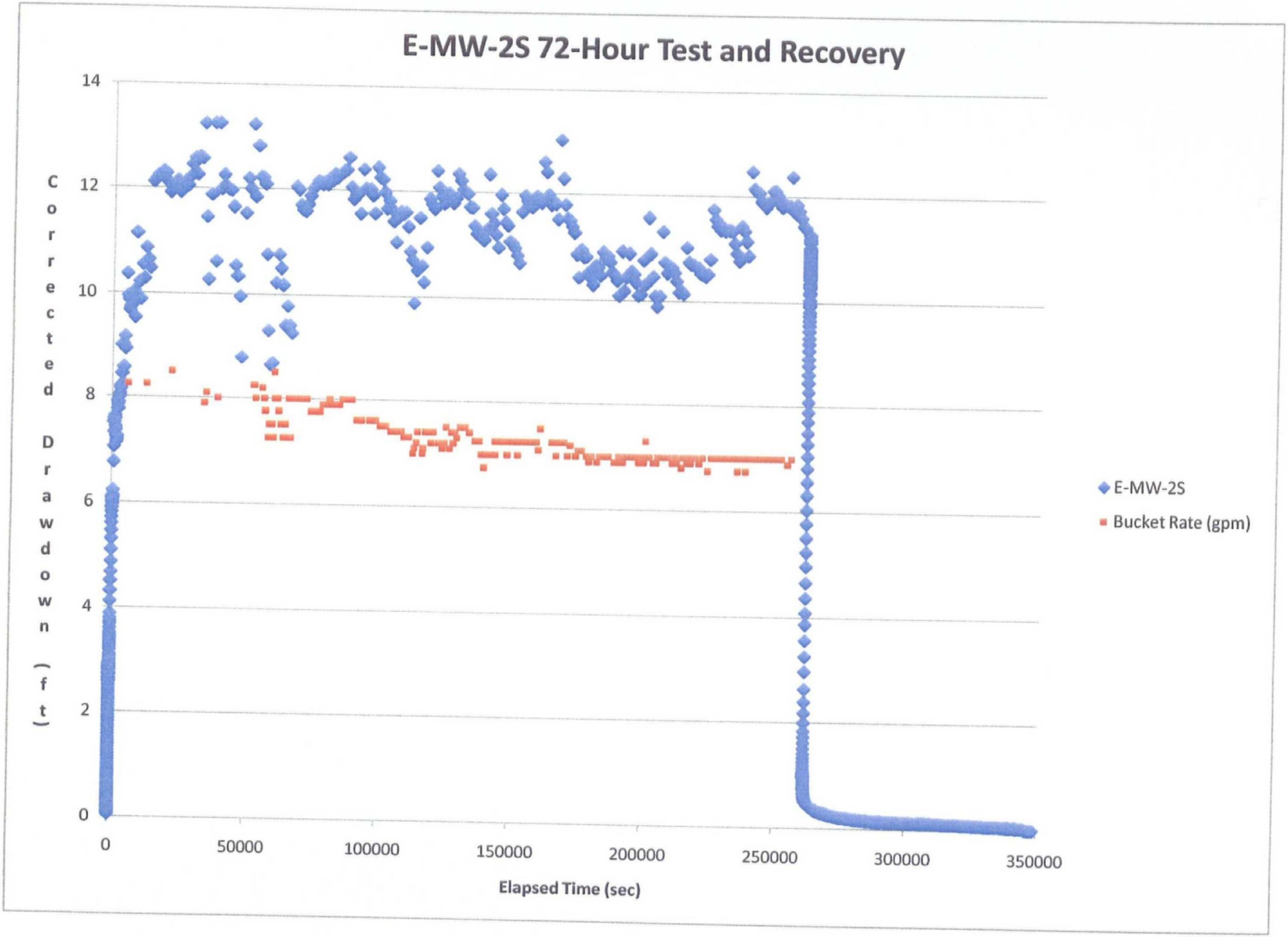

MW-6S Background Pre-Step Test
y = 8E-07x + 11.45
Depth to Water (ft)
11.52
11.51
11.5
11.49
11.48
11.47
11.46
11.45
11.44
11.43
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
Elapsed Time
Background
Linear (Background)

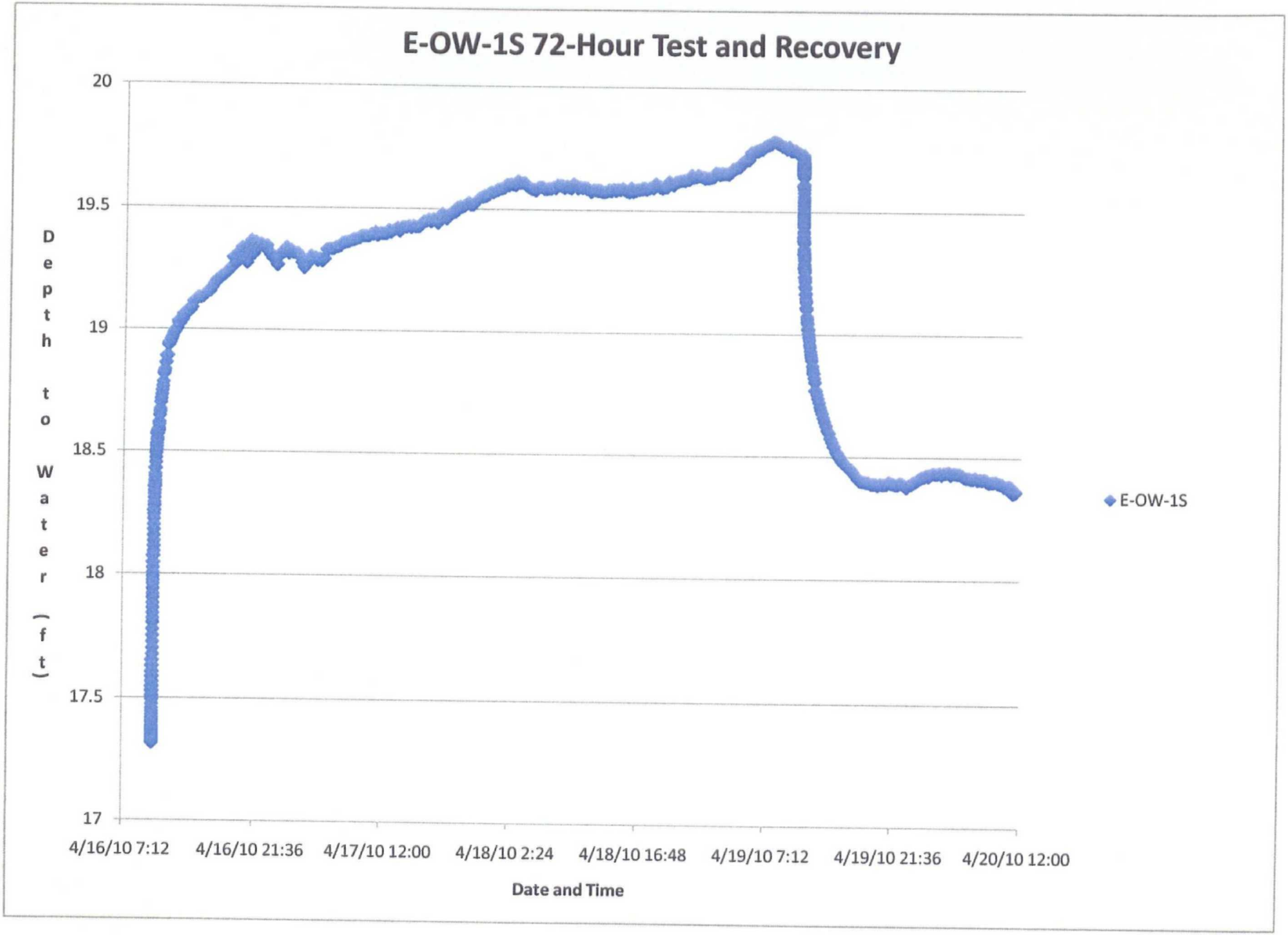
APPENDIX D

72-HOUR SUSTAINABLE RATE TEST OBSERVATION DATA PLOTS

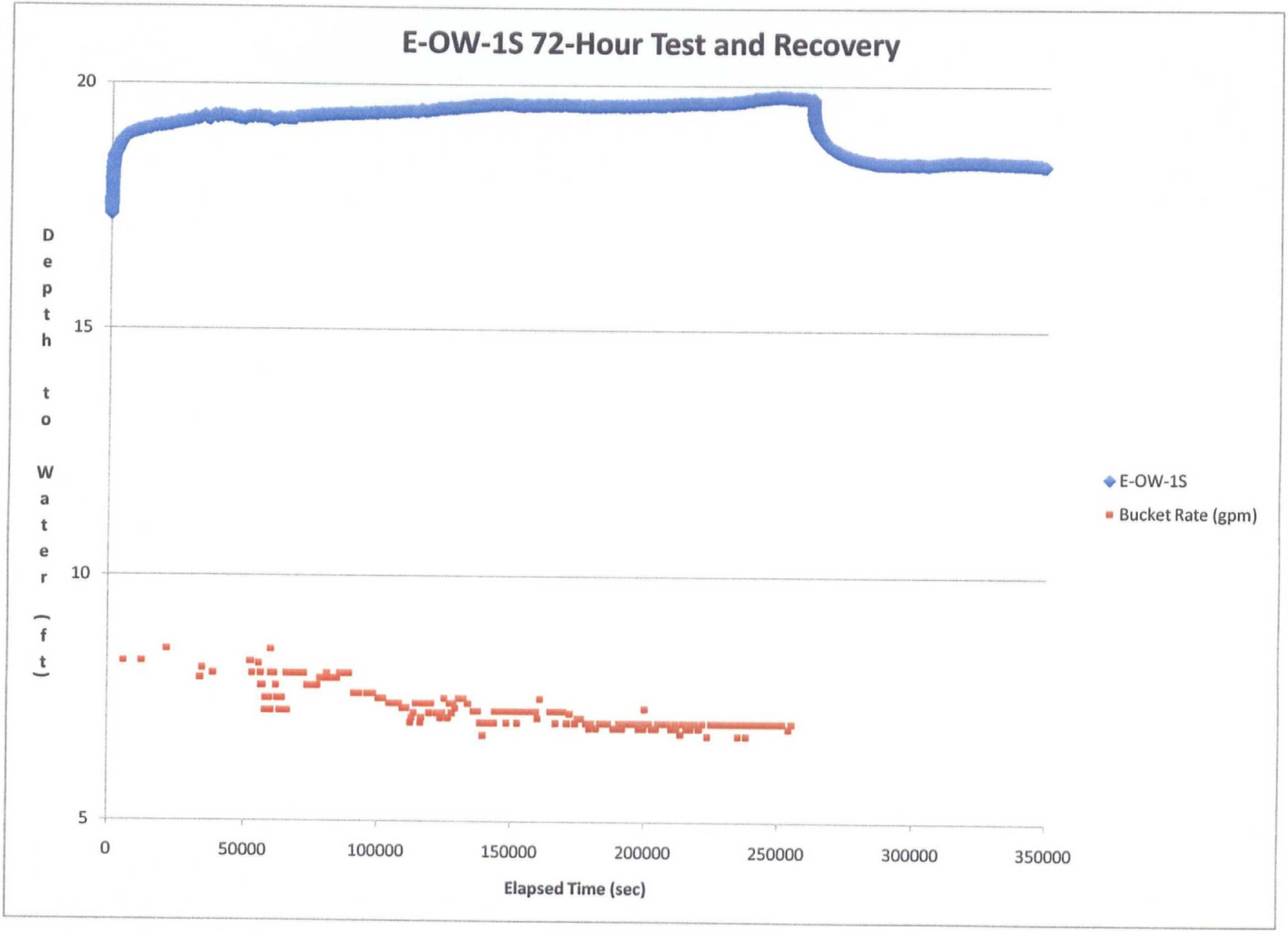

E-MW-2S 72-Hour Test and Recovery
Depth to Water (ft)
28
26
24
22
20
18
16
14
4/16/10 7:12
4/16/10 21:36
4/17/10 12:00
4/18/10 2:24
4/18/10 16:48
4/19/10 7:12
4/19/10 21:36
4/20/10 12:00
Date and Time
E-MW-2S

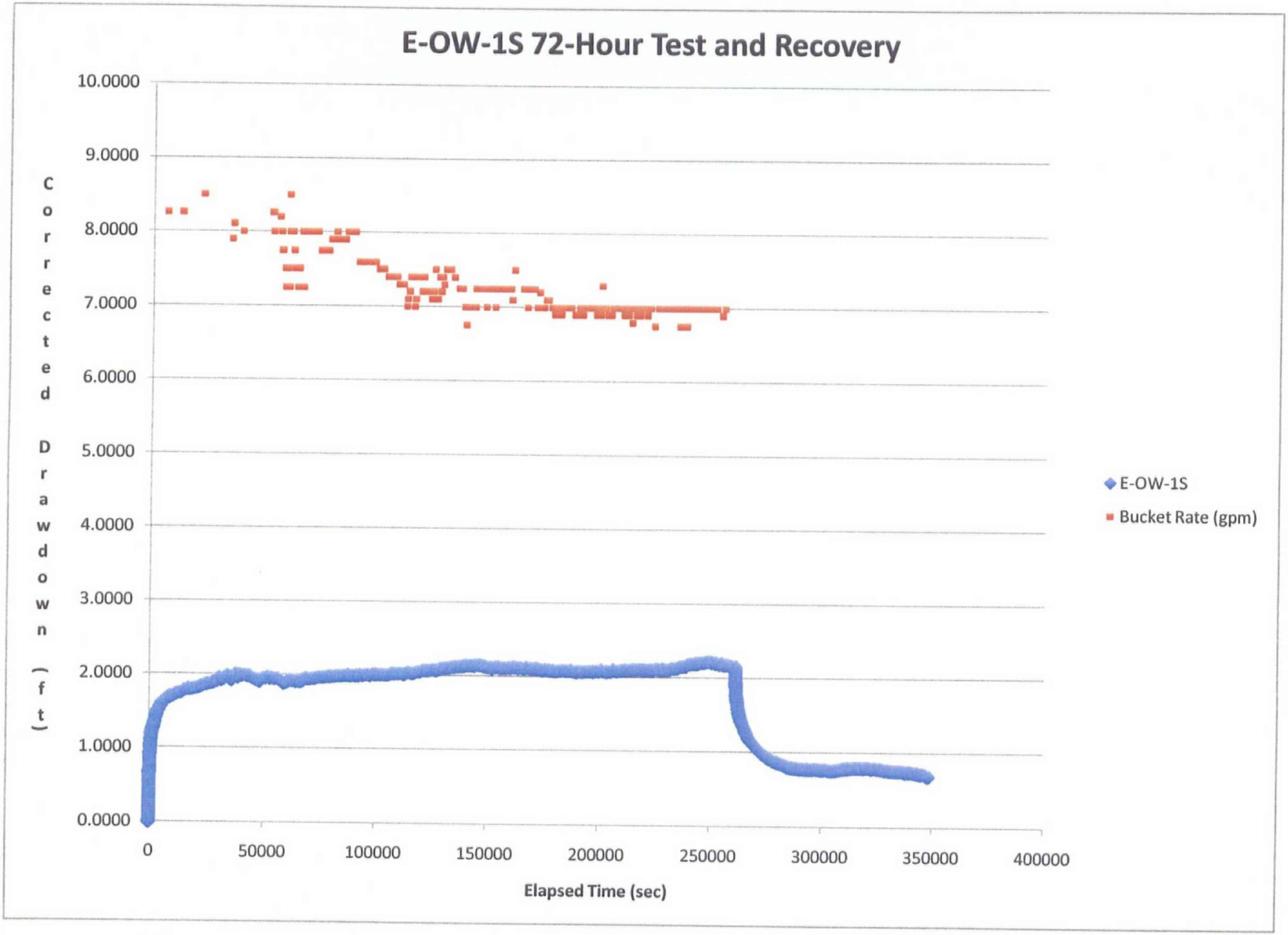

E-MW-2S 72-Hour Test and Recovery
Depth to Water (ft)
30
25
20
15
10
5
0
50000
100000
150000
200000
250000
300000
350000
Elapsed Time (sec)
E-MW-2S
Bucket Rate (gpm)

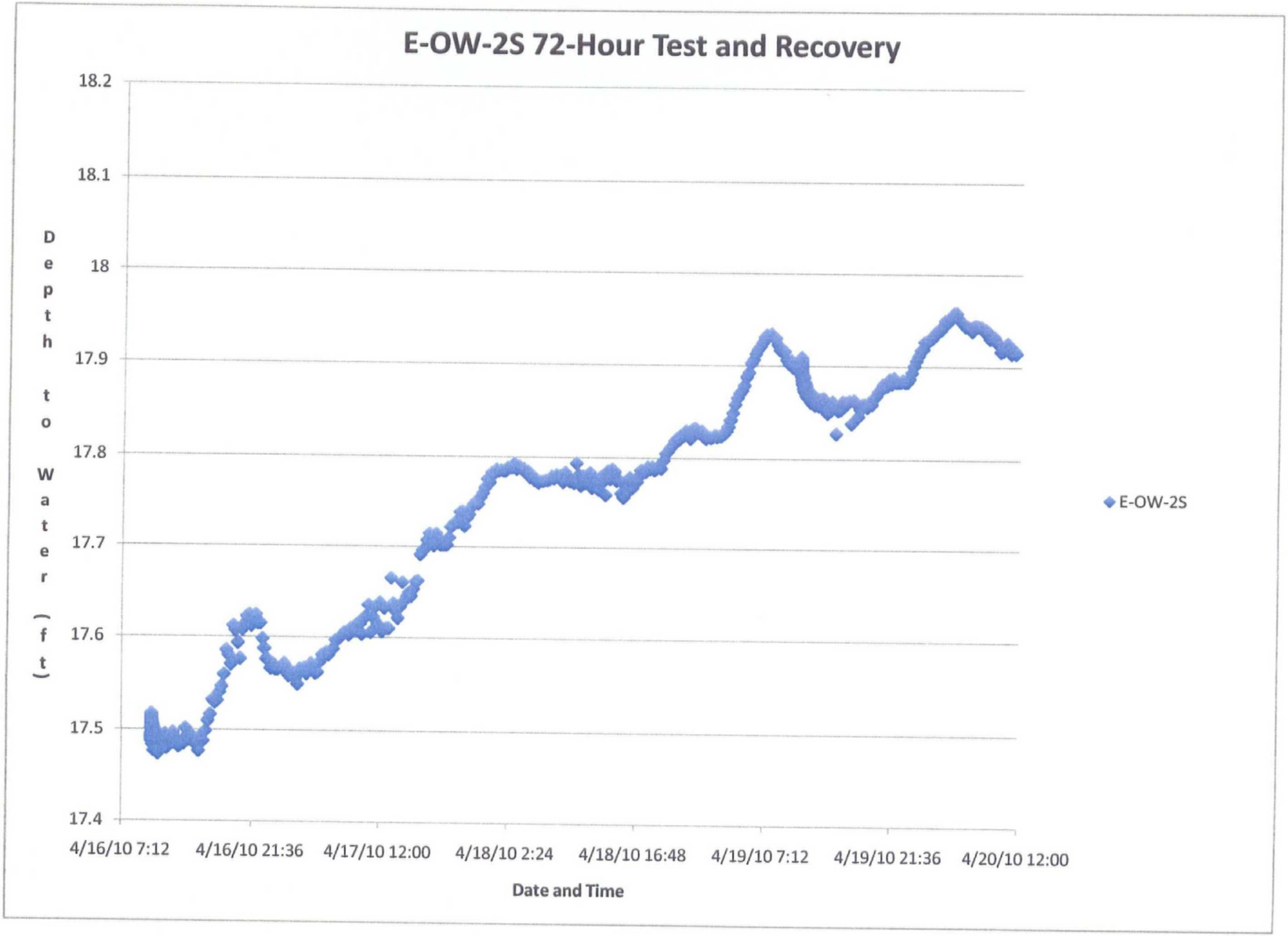

E-MW-2S 72-Hour Test and Recovery
Corrected Drawdown (ft)
0
2
4
6
8
10
12
14
0
50000
100000
150000
200000
250000
300000
350000
Elapsed Time (sec)
E-MW-2S
Bucket Rate (gpm)

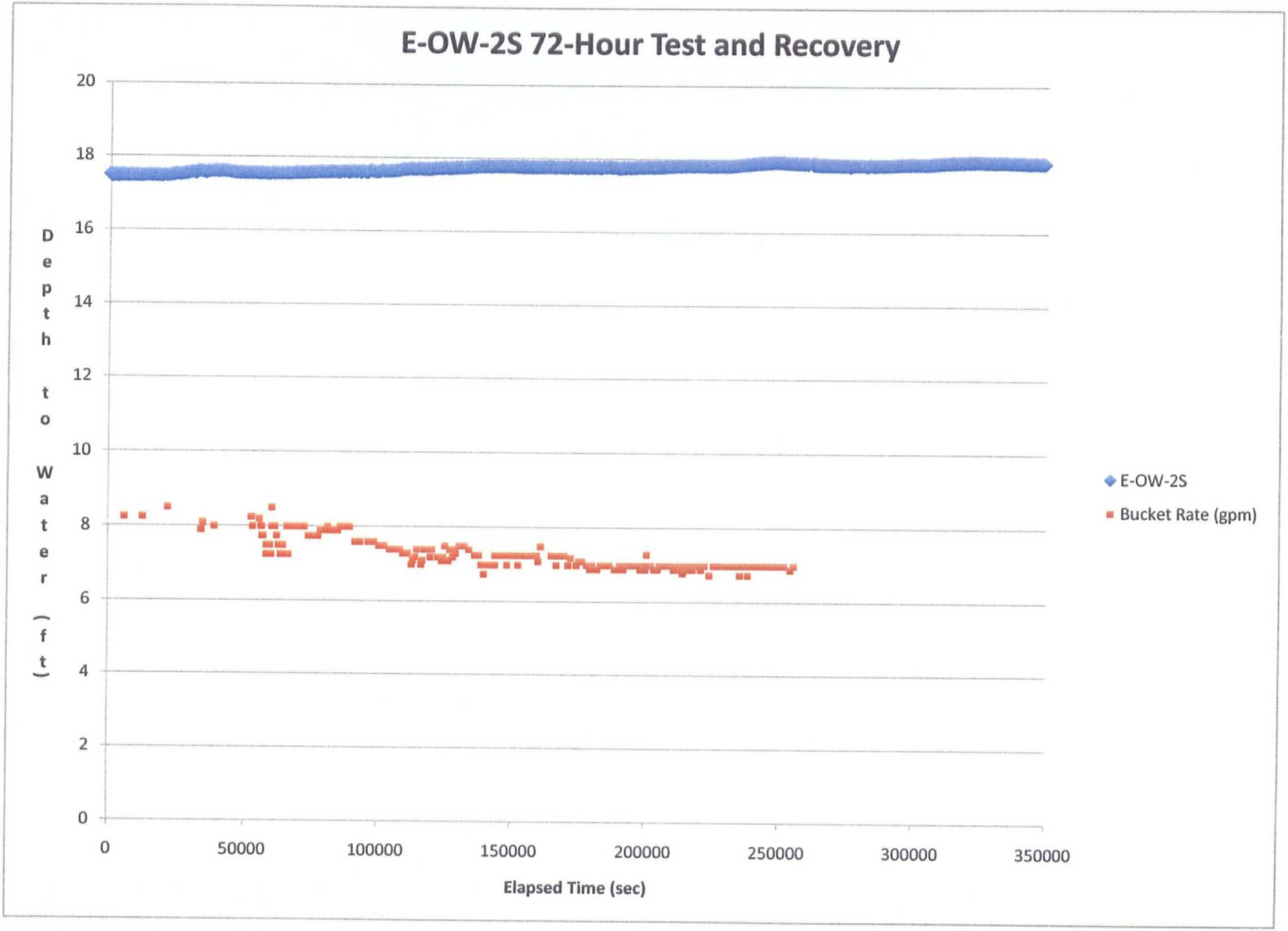


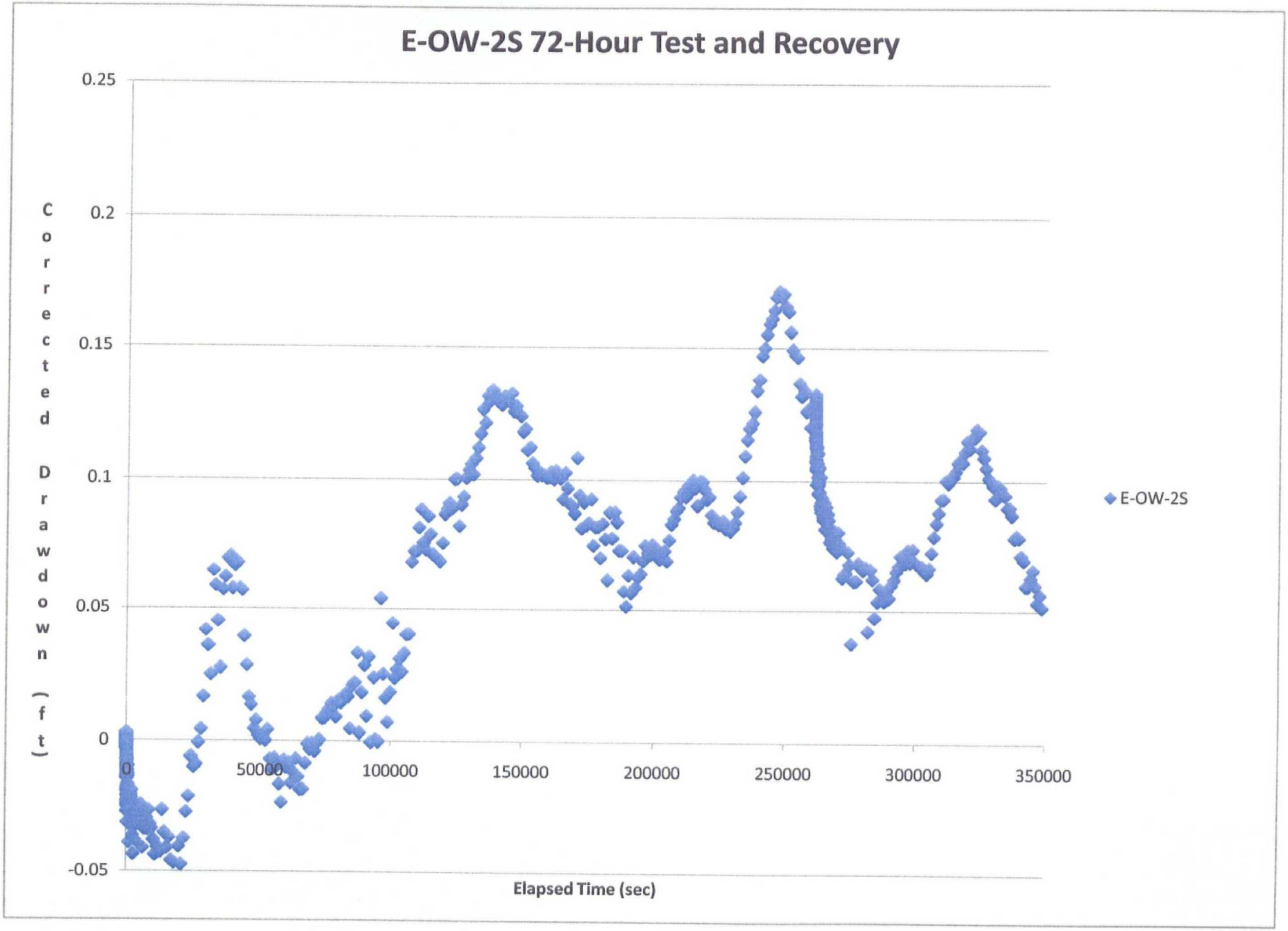
E-OW-1S 72-Hour Test and Recovery
20
19.5
19
18.5
18
17.5
17
Depth to Water (ft)
4/16/10 7:12
4/16/10 21:36
4/17/10 12:00
4/18/10 2:24
4/18/10 16:48
4/19/10 7:12
4/19/10 21:36
4/20/10 12:00
Date and Time
E-OW-1S

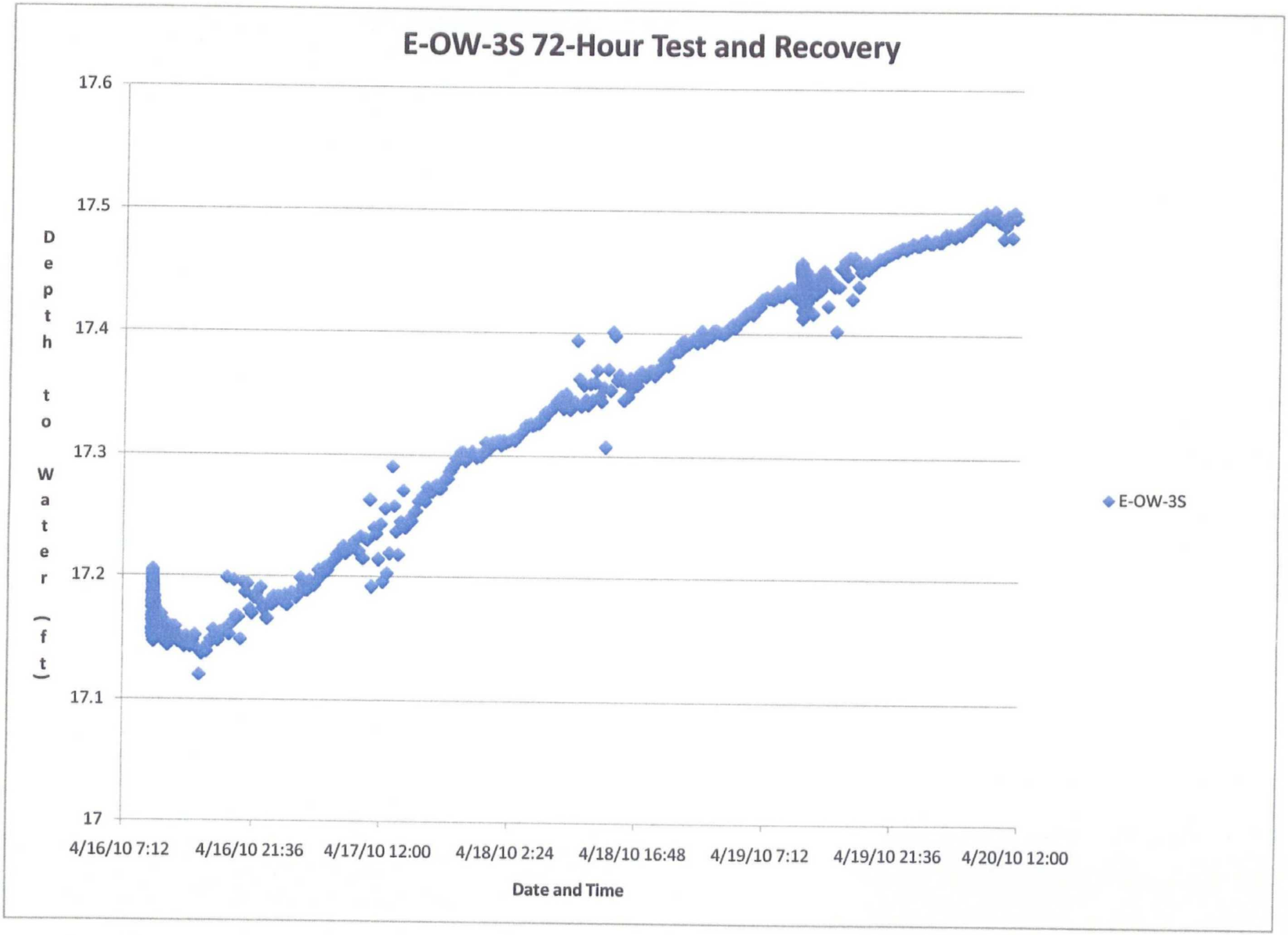

E-OW-1S 72-Hour Test and Recovery
Depth to Water (ft)
20
15
10
5
0
50000
100000
150000
200000
250000
300000
350000
Elapsed Time (sec)
E-OW-1S
Bucket Rate (gpm)

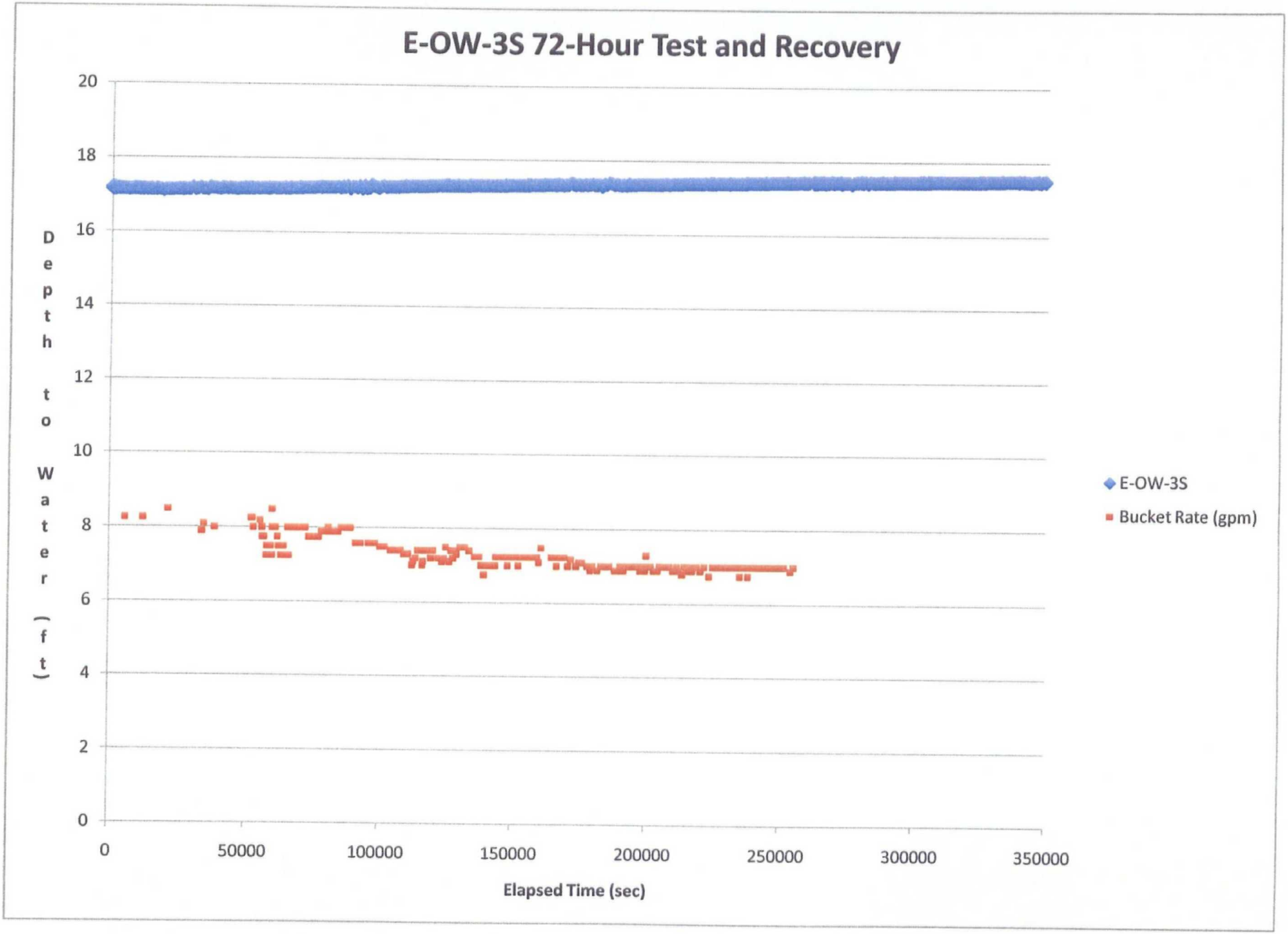

E-OW-1S 72-Hour Test and Recovery
Corrected Drawdown (ft)
10.0000
9.0000
8.0000
7.0000
6.0000
5.0000
4.0000
3.0000
2.0000
1.0000
0.0000
0
50000
100000
150000
200000
250000
300000
350000
400000
Elapsed Time (sec)
E-OW-1S
Bucket Rate (gpm)

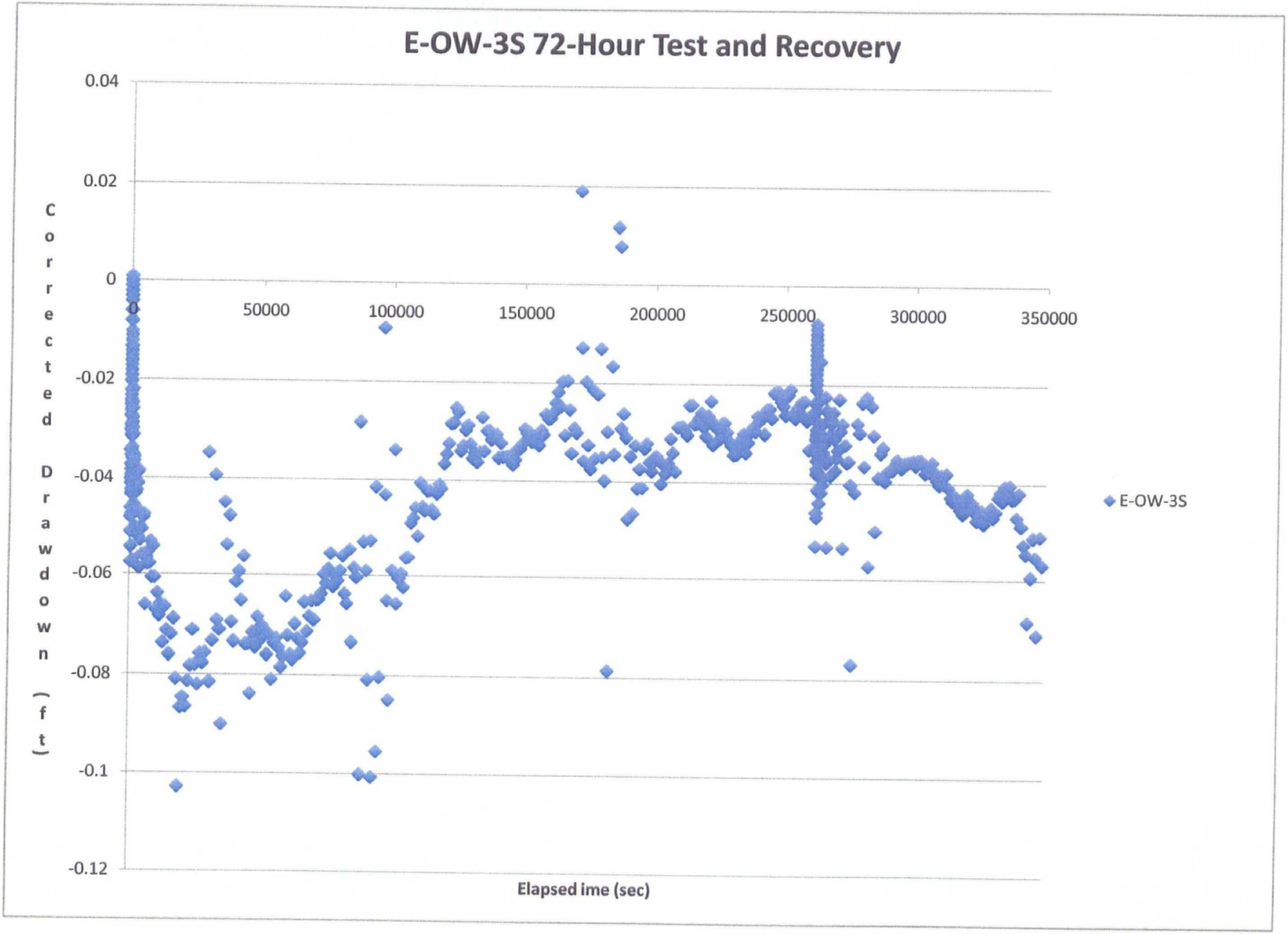

E-OW-2S 72-Hour Test and Recovery
Depth to Water (ft)
18.2
18.1
18
17.9
17.8
17.7
17.6
17.5
17.4
4/16/10 7:12
4/16/10 21:36
4/17/10 12:00
4/18/10 2:24
4/18/10 16:48
4/19/10 7:12
4/19/10 21:36
4/20/10 12:00
Date and Time
E-OW-2S


E-OW-2S 72-Hour Test and Recovery
Depth to Water (ft)
20
18
16
14
12
10
8
6
4
2
0
0
50000
100000
150000
200000
250000
300000
350000
Elapsed Time (sec)
E-OW-2S
Bucket Rate (gpm)


E-OW-2S 72-Hour Test and Recovery
Corrected Drawdown (ft)
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
50000
100000
150000
200000
250000
300000
350000
Elapsed Time (sec)
E-OW-2S


E-OW-3S 72-Hour Test and Recovery
17.6
17.5
17.4
17.3
17.2
17.1
17
Depth to Water (ft)
4/16/10 7:12
4/16/10 21:36
4/17/10 12:00
4/18/10 2:24
4/18/10 16:48
4/19/10 7:12
4/19/10 21:36
4/20/10 12:00
Date and Time
E-OW-3S

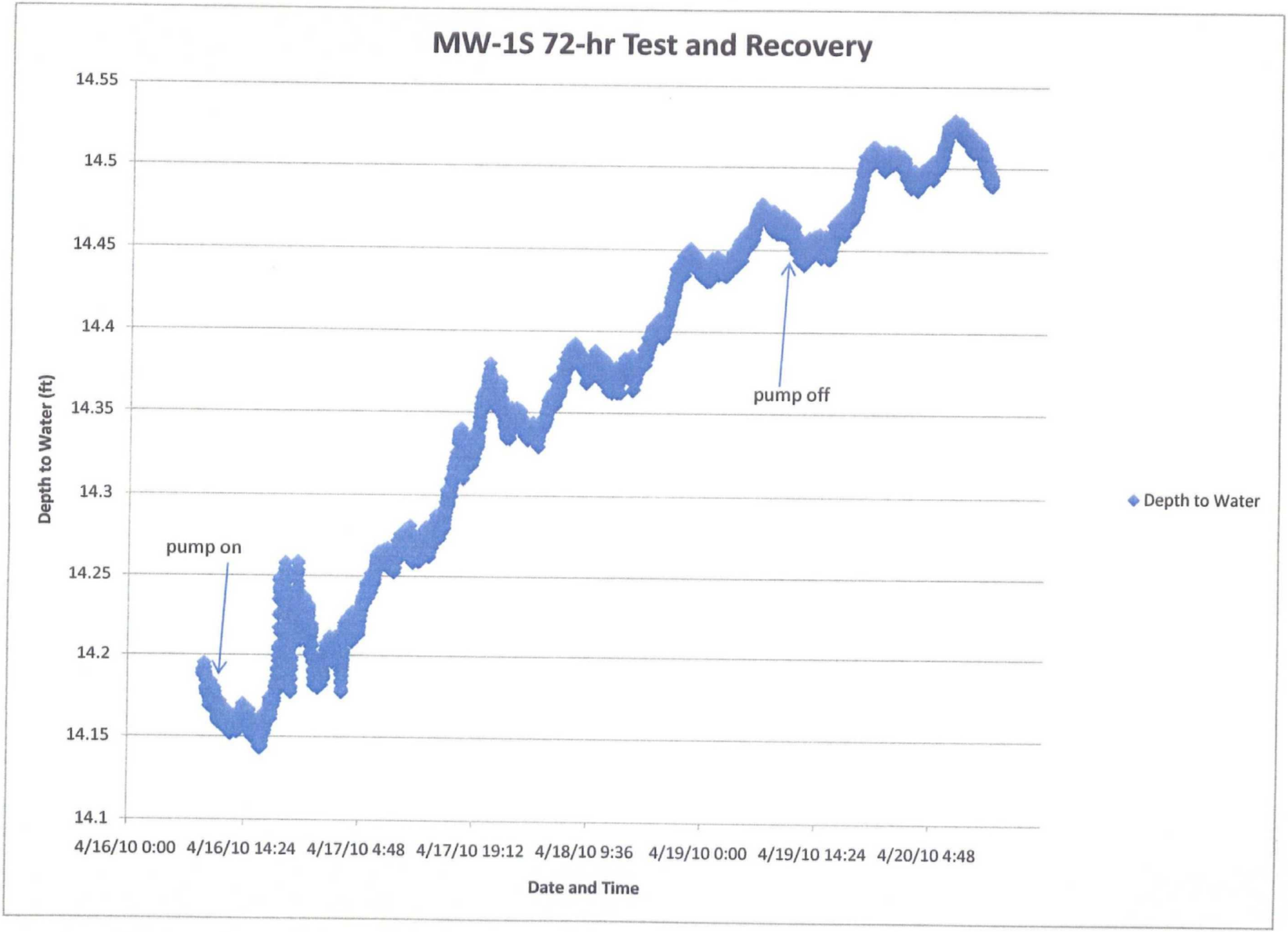

E-OW-3S 72-Hour Test and Recovery
Depth to Water (ft)
20
18
16
14
12
10
8
6
4
2
0
0
50000
100000
150000
200000
250000
300000
350000
Elapsed Time (sec)
E-OW-3S
Bucket Rate (gpm)

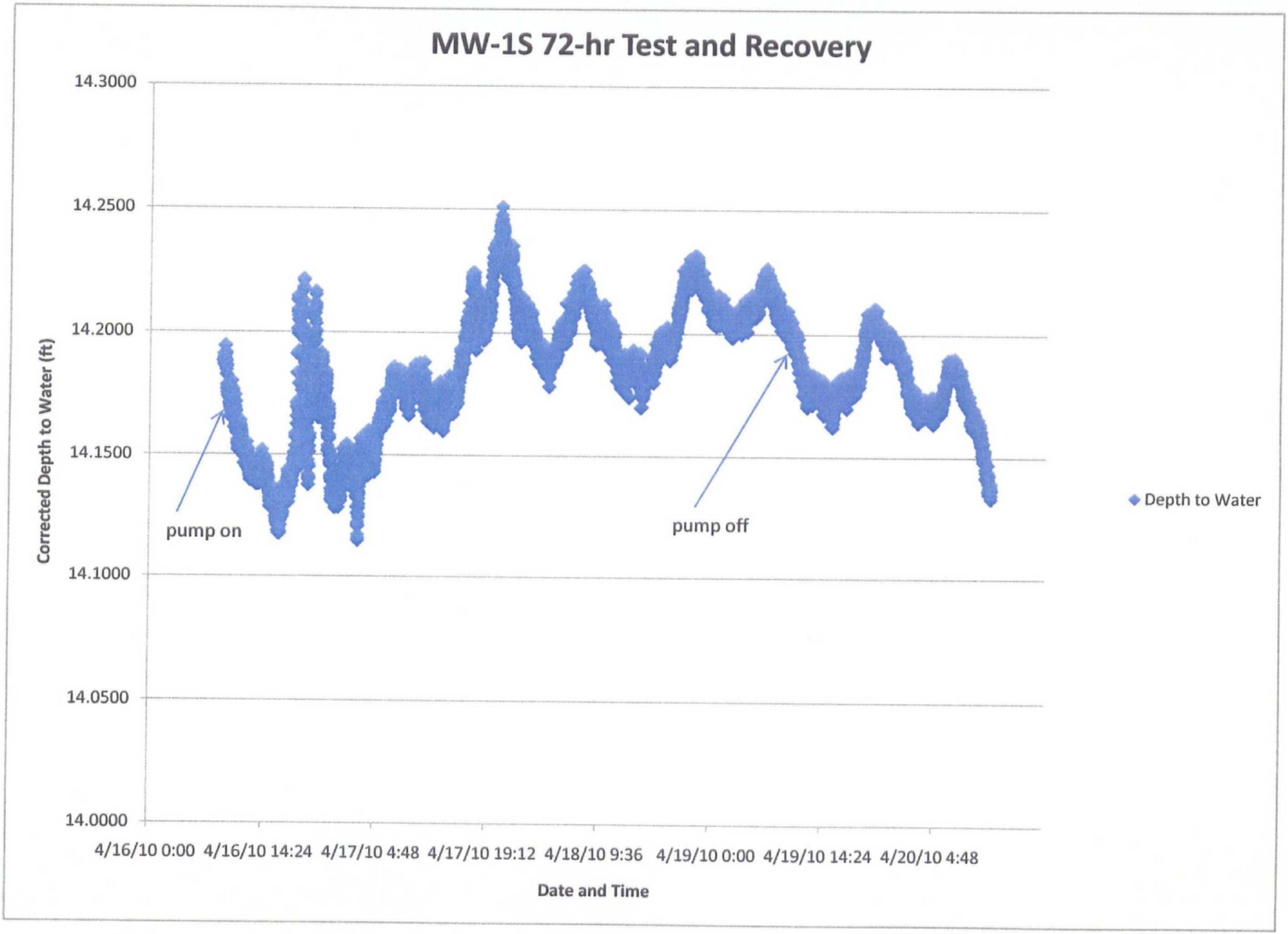


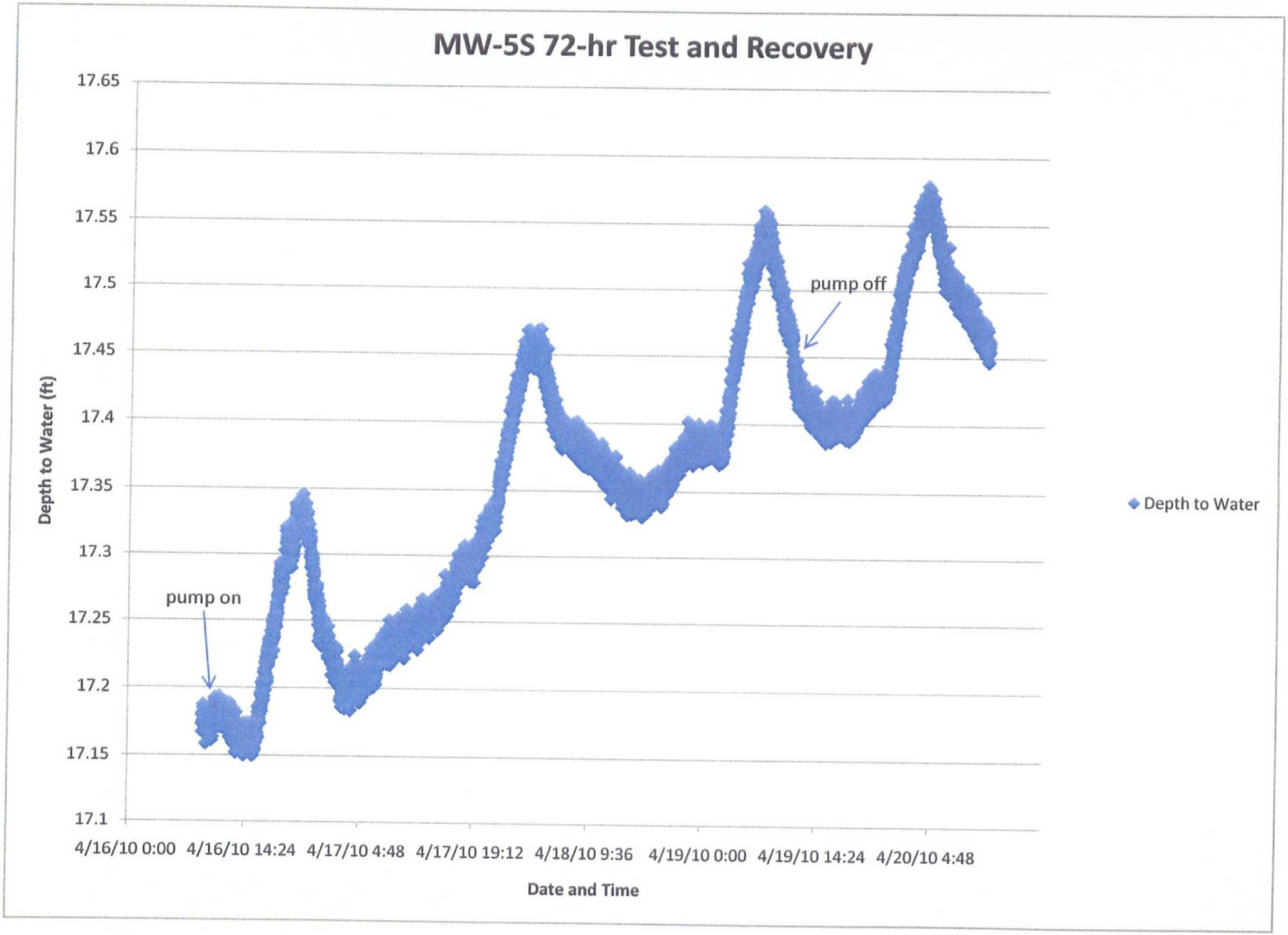
E-OW-3S 72-Hour Test and Recovery
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
Corrected Drawdown (ft)
0
50000
100000
150000
200000
250000
300000
350000
Elapsed ime (sec)
E-OW-3S

APPENDIX E

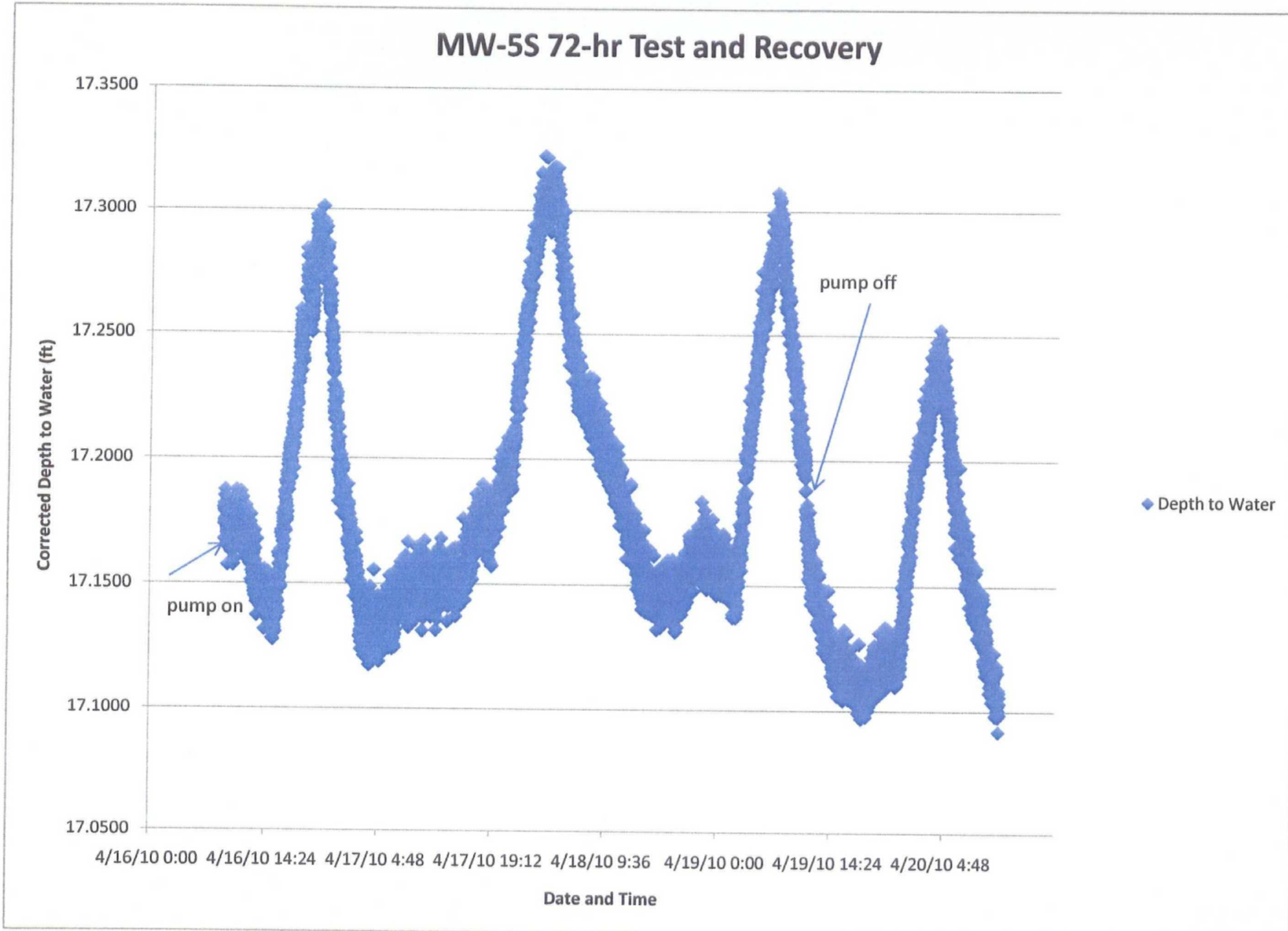
RADIUS OF INFLUENCE DATA PLOTS


MW-1S 72-hr Test and Recovery
Depth to Water (ft)
14.55
14.5
14.45
14.4
14.35
14.3
14.25
14.2
14.15
14.1
pump on
pump off
Depth to Water
4/16/10 0:00
4/16/10 14:24
4/17/10 4:48
4/17/10 19:12
4/18/10 9:36
4/19/10 0:00
4/19/10 14:24
4/20/10 4:48
Date and Time

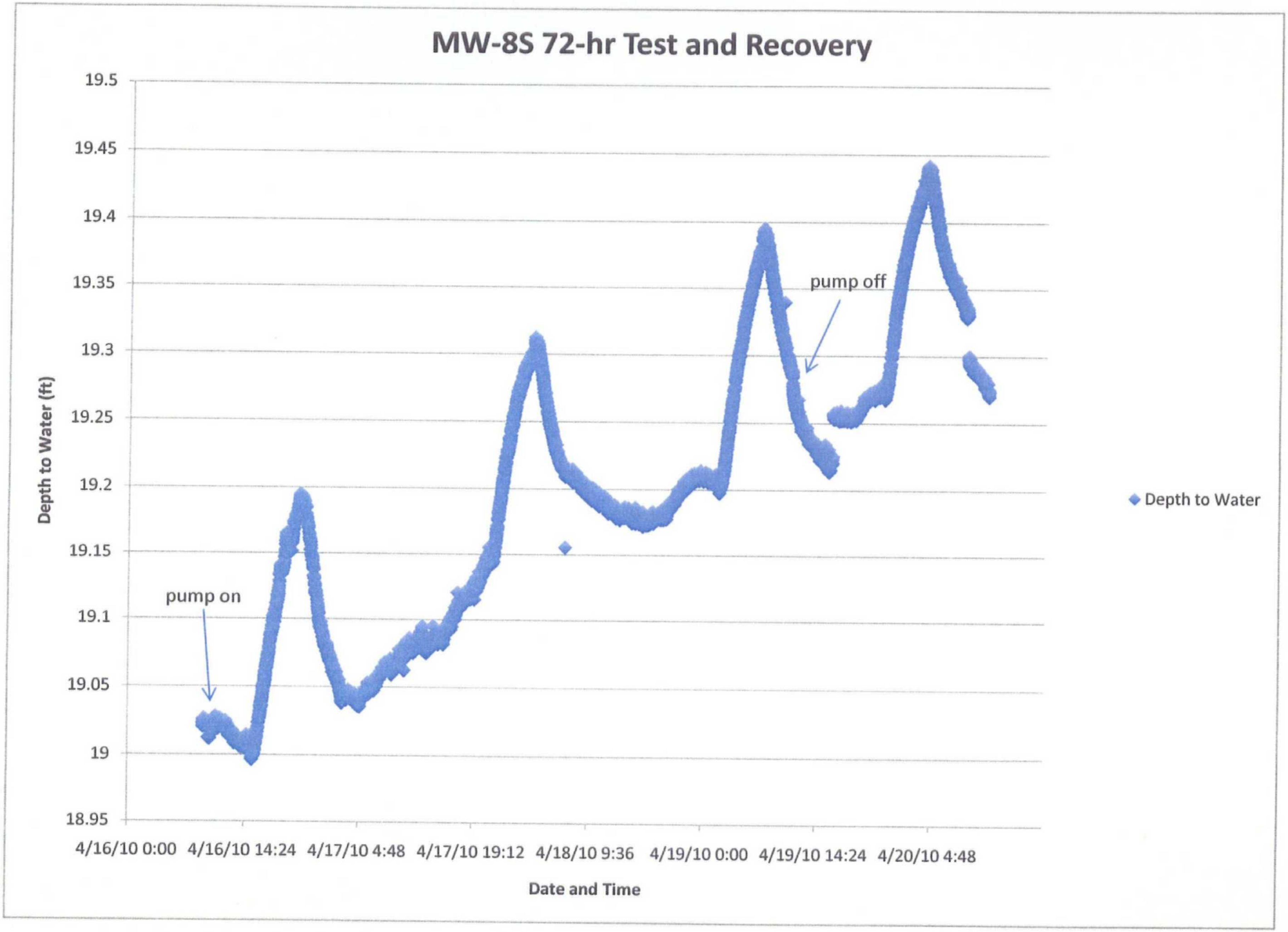

MW-1S 72-hr Test and Recovery
14.3000
14.2500
14.2000
14.1500
14.1000
14.0500
14.0000
Corrected Depth to Water (ft)
pump on
pump off
Depth to Water
4/16/10 0:00
4/16/10 14:24
4/17/10 4:48
4/17/10 19:12
4/18/10 9:36
4/19/10 0:00
4/19/10 14:24
4/20/10 4:48
Date and Time



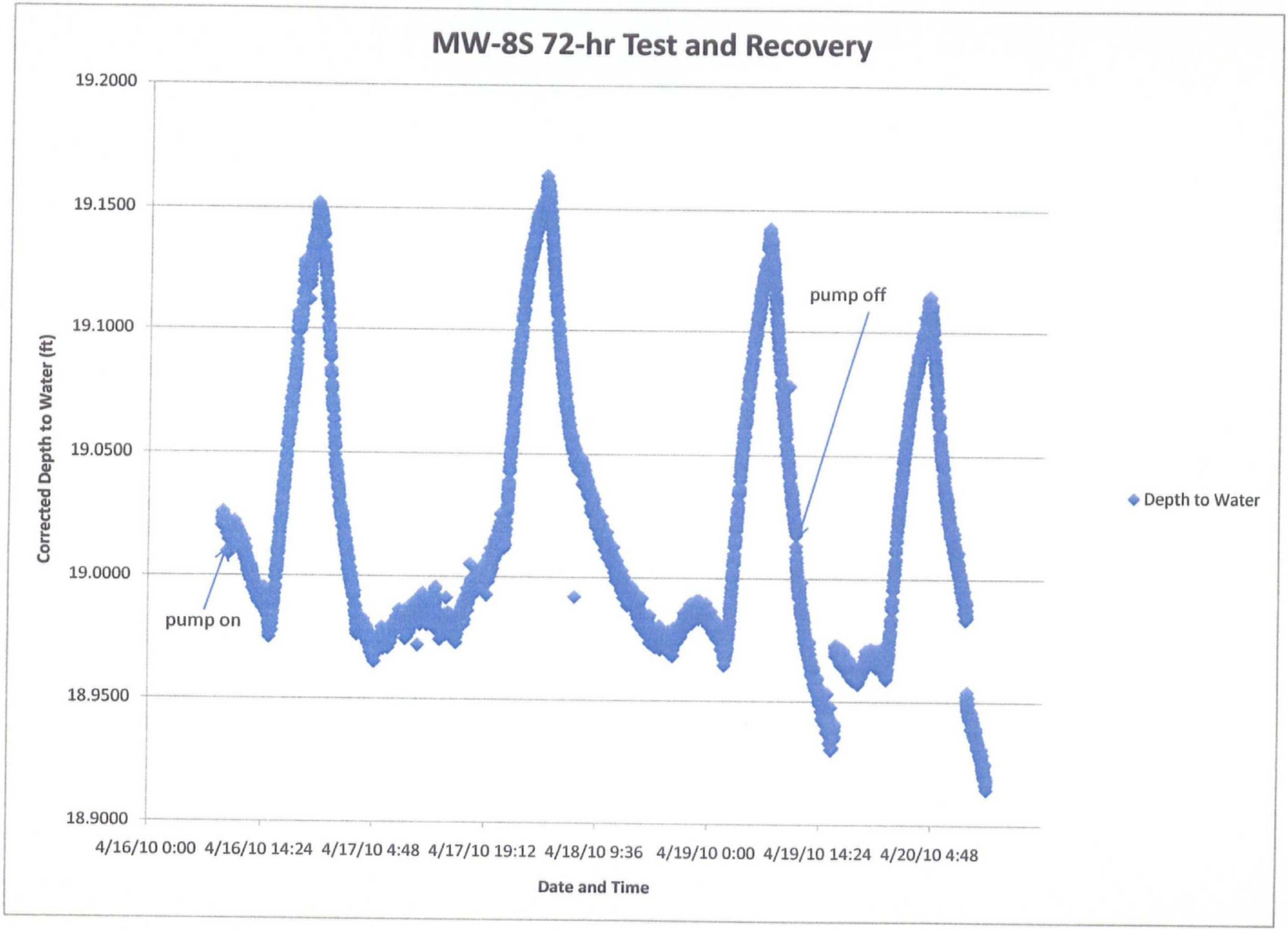
MW-5S 72-hr Test and Recovery
Depth to Water (ft)
17.65
17.6
17.55
17.5
17.45
17.4
17.35
17.3
17.25
17.2
17.15
17.1
pump on
pump off
4/16/10 0:00
4/16/10 14:24
4/17/10 4:48
4/17/10 19:12
4/18/10 9:36
4/19/10 0:00
4/19/10 14:24
4/20/10 4:48
Date and Time
Depth to Water



MW-5S 72-hr Test and Recovery
17.3500
17.3000
17.2500
17.2000
17.1500
17.1000
17.0500
Corrected Depth to Water (ft)
pump on
pump off
Depth to Water
4/16/10 0:00
4/16/10 14:24
4/17/10 4:48
4/17/10 19:12
4/18/10 9:36
4/19/10 0:00
4/19/10 14:24
4/20/10 4:48
Date and Time



MW-8S 72-hr Test and Recovery
19.5
19.45
19.4
19.35
19.3
19.25
19.2
19.15
19.1
19.05
19
18.95
Depth to Water (ft)
pump on
pump off
4/16/10 0:00
4/16/10 14:24
4/17/10 4:48
4/17/10 19:12
4/18/10 9:36
4/19/10 0:00
4/19/10 14:24
4/20/10 4:48
Date and Time
Depth to Water


MW-8S 72-hr Test and Recovery
Corrected Depth to Water (ft)
19.2000
19.1500
19.1000
19.0500
19.0000
18.9500
18.9000
pump on
pump off
Depth to Water
4/16/10 0:00
4/16/10 14:24
4/17/10 4:48
4/17/10 19:12
4/18/10 9:36
4/19/10 0:00
4/19/10 14:24
4/20/10 4:48
Date and Time

APPENDIX F

STEP-DRAWDOWN TEST ANALYSIS

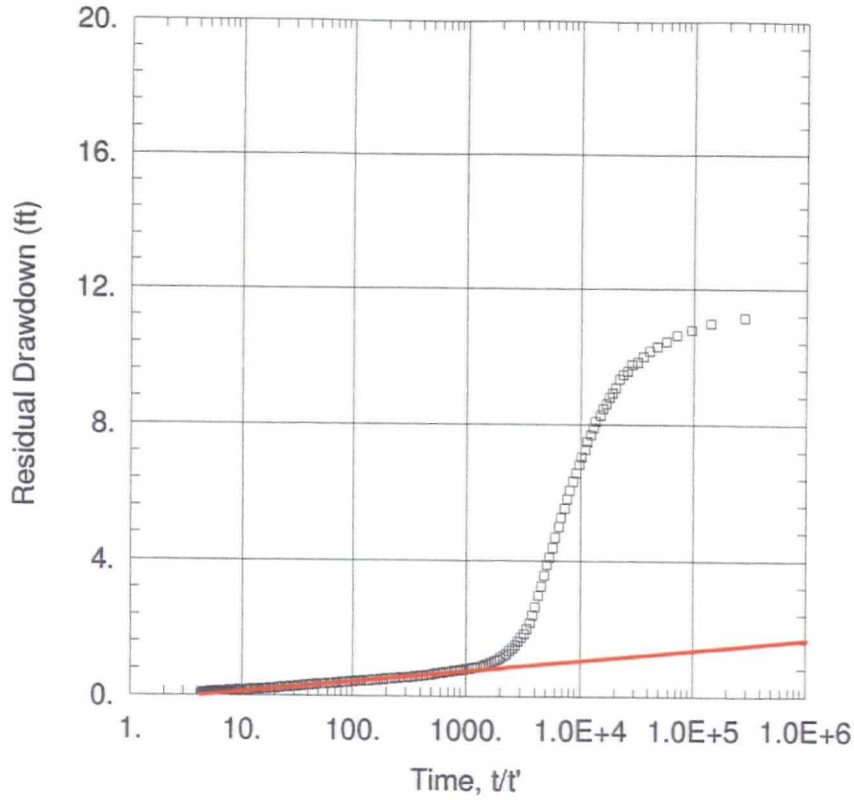
K_h (cm/sec)	4.00E-03	
Initial Sat. Thickness (ft)	35	
Pumping Rate (gpm)	8.5	
Sy	0.2	fine-sand average (Fetter, 1994)
time (hours)	5	
K_v/K_h	0.1	e.g., Walton, 1996
K_v (cm/sec)	4.00E-04	

Theis solution for drawdown
(Well function with Kv/Kh) E-MW-2S

observation points		Obs Well	Well		Pump rate	Transmissivity	Storativity	time	distance				App 6B Fetter (1994)	drawdown
x(l)	y(l)		x	y	Q (ft3/day)	T (ft^2/day)	s	t (days)	r(l)	u_B	$1/u_B$	τ	$W(u_B, \tau)$	(ft)
4	0	E-OW-1S	0	0	1636.2	396.7	0.2	0.208	4	0.01	1.0E+02	0.001	5.83	1.91
110	0	E-OW-2S							110	7.319	1.4E-01	0.988	0.35	0.11

APPENDIX G

E-MW2S AQTESOLV PLOTS



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\...\Theis Resid DD E-MW-2S.aqt
Date: 05/06/10 Time: 09:41:55

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

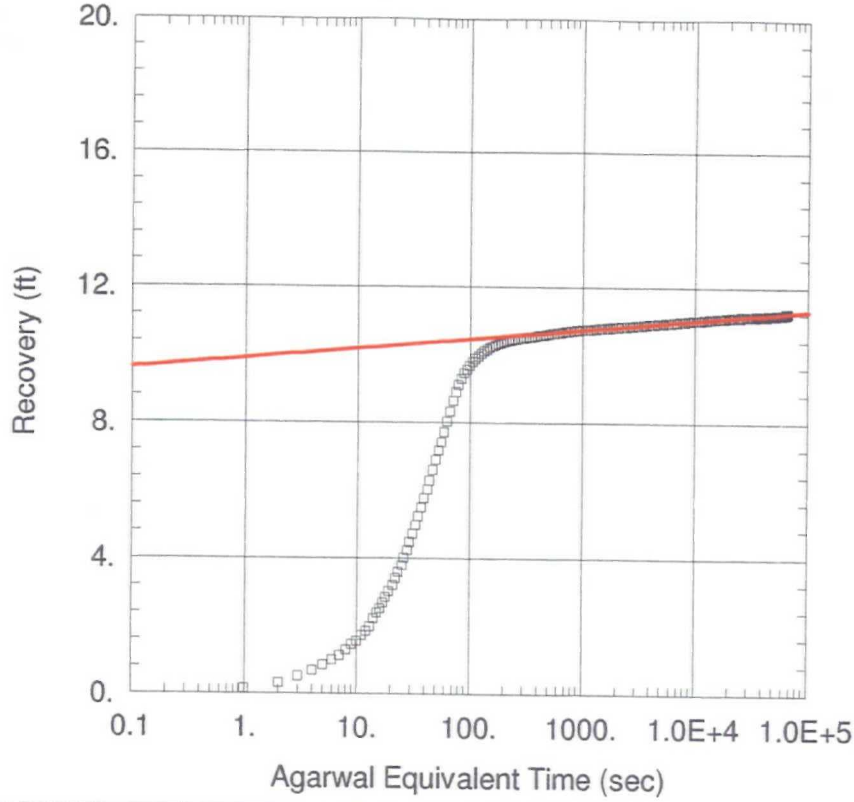
Observation Wells

Well Name	X (ft)	Y (ft)
□ E-MW-2S	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 8.533 cm^2/sec S/S' = 4.192



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\...\Cooper Agarwal Recovery E-MW-2S.aqt
Date: 05/06/10 Time: 09:39:48

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft
Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

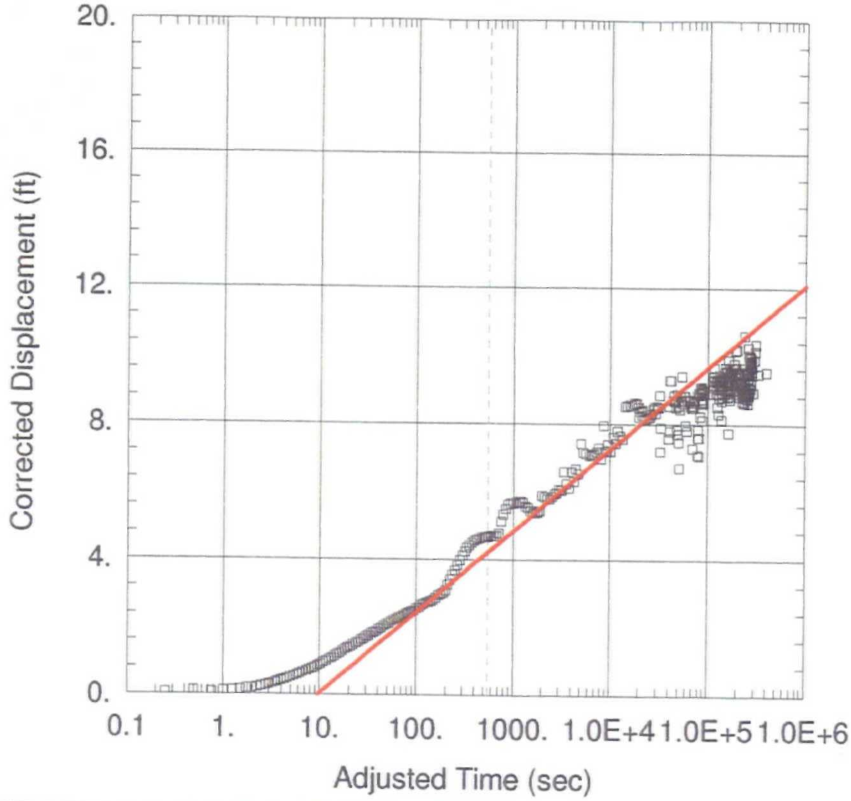
Observation Wells

Well Name	X (ft)	Y (ft)
▫ E-MW-2S	0	0

SOLUTION

Aquifer Model: Unconfined
Solution Method: Cooper-Jacob

T = 9.427 cm^2/sec
S = 1.195E-36



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\...\Cooper First Cut E-MW-2S.aqt
Date: 05/06/10 Time: 09:40:24

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

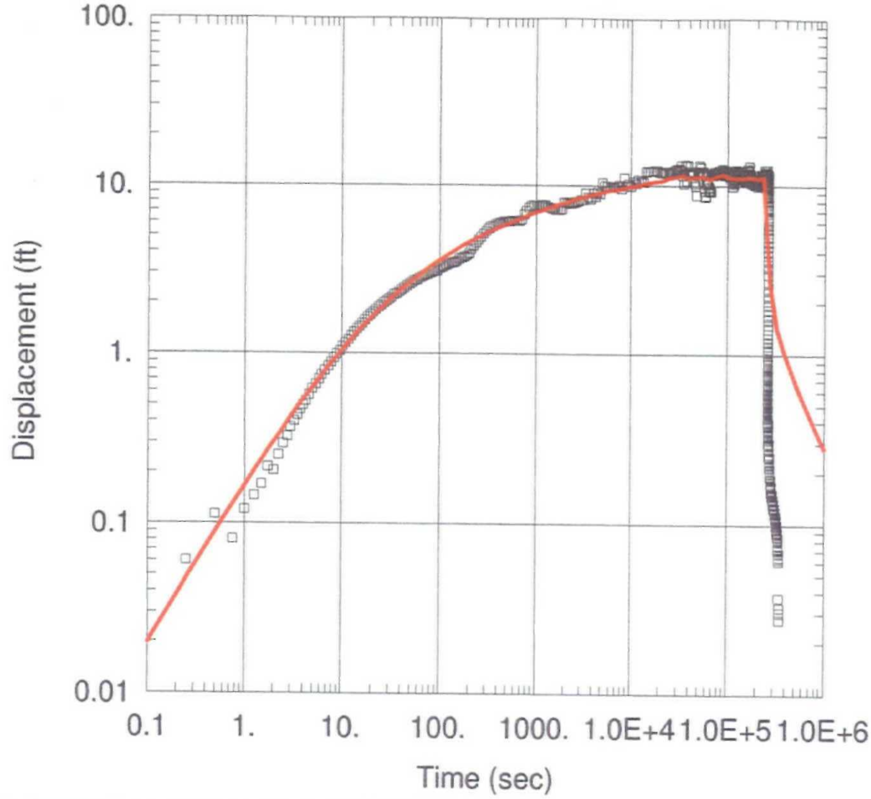
Observation Wells

Well Name	X (ft)	Y (ft)
□ E-MW-2S	0	0

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 1.1 cm^2/sec S = 0.1844



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\FAA\Area E\Pumping Test Data\Monday 930\Aqtesolv\EMW-2S\Moench E-MW-2S.aqt
Date: 05/06/10 Time: 09:41:08

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ E-MW-2S	0	0

SOLUTION

Aquifer Model: Unconfined

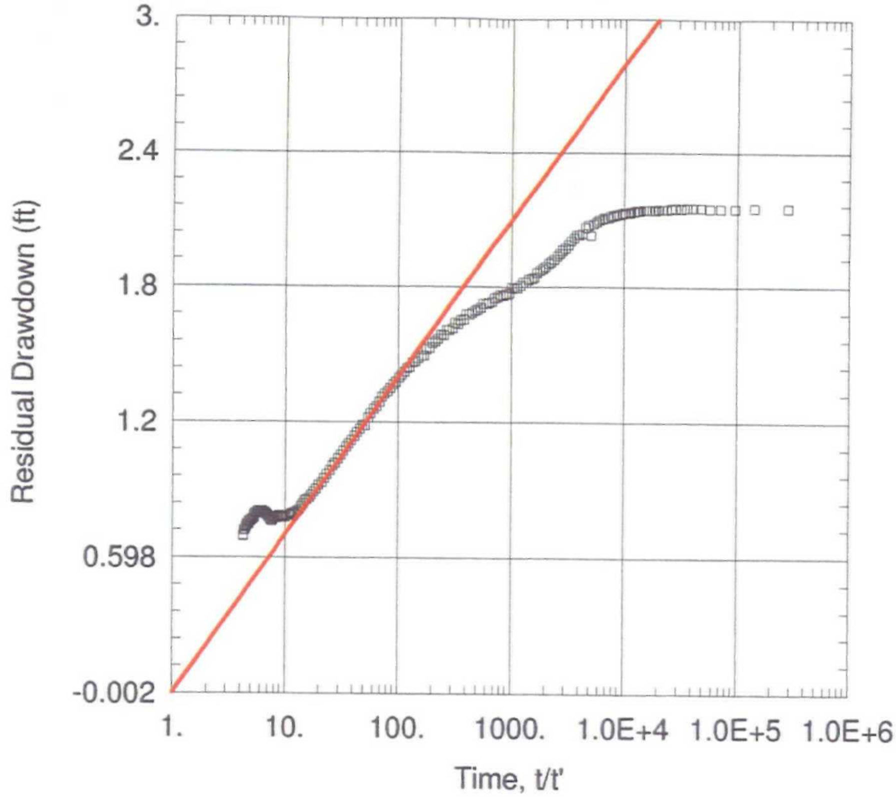
T = 1.557 cm^2/sec
Sy = 0.2447
Sw = 0.
r(c) = 0.1667 ft

Solution Method: Moench

S = 0.2745
ß = 2.296E-5
r(w) = 0.375 ft
alpha = 1.0E+30 sec^{-1}

APPENDIX H

E-OW1S AQTESOLV PLOTS



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\...\Theis Resid DD E-OW-1S.aqt
Date: 05/06/10 Time: 09:38:59

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

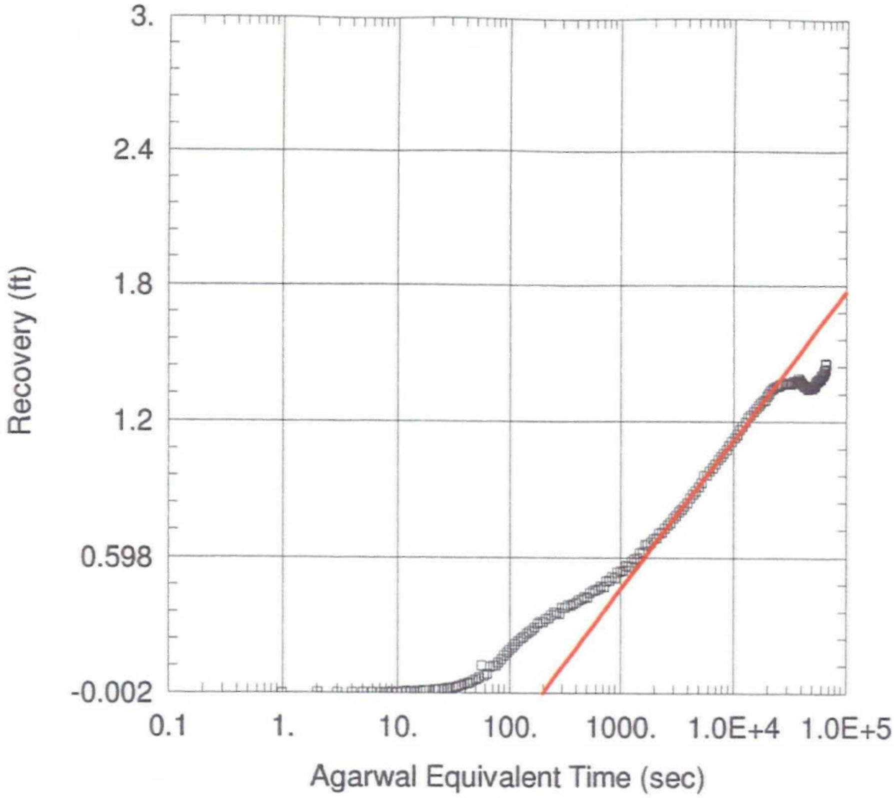
Observation Wells

Well Name	X (ft)	Y (ft)
□ E-OW-1S	4.33	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 3.8 cm^2/sec S/S' = 1.



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\...\Cooper Agarwal Recovery E-OW-1S.aqt
Date: 05/06/10 Time: 09:35:05

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

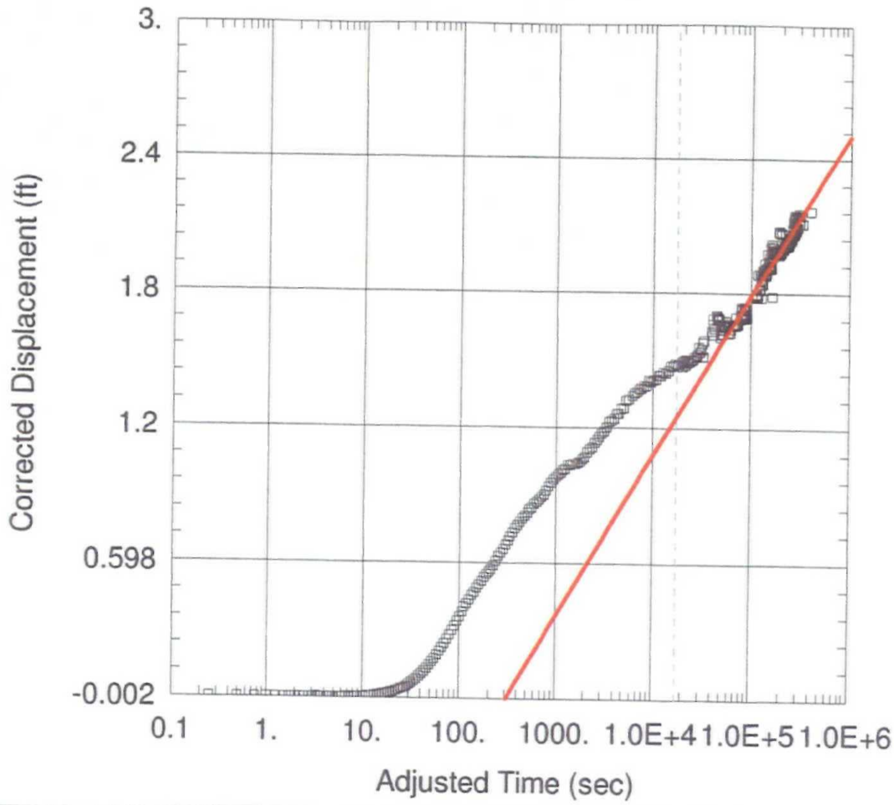
Observation Wells

Well Name	X (ft)	Y (ft)
□ E-OW-1S	4.33	0

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 4.055 cm^2/sec S = 0.1042



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\...\Cooper First Cut E-OW-1S.aqt
Date: 05/06/10 Time: 09:37:02

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

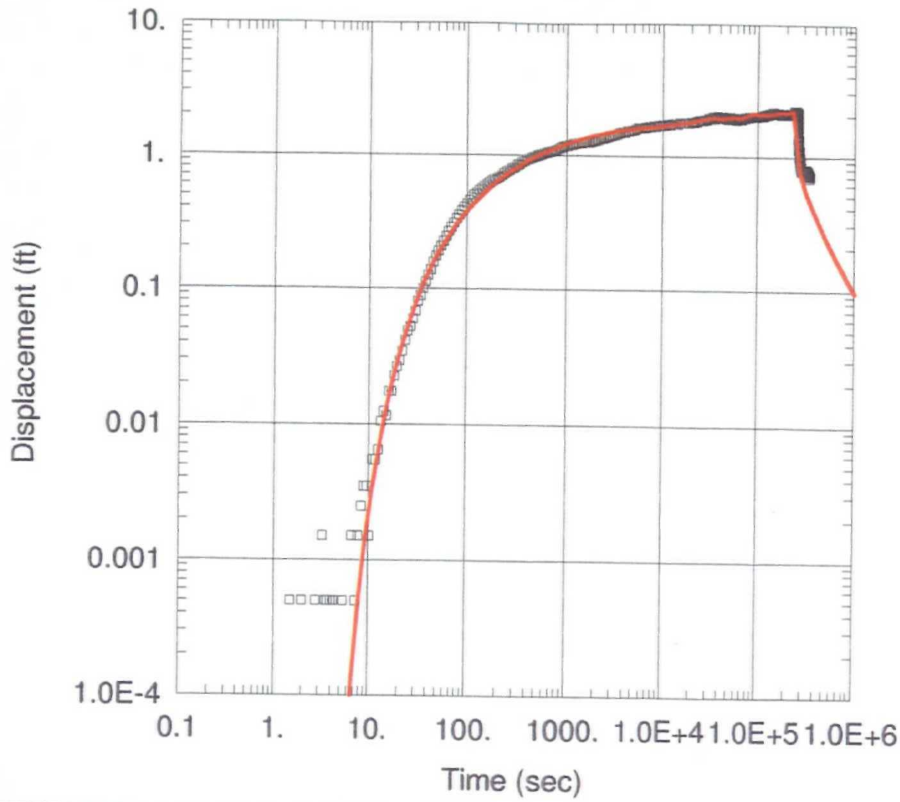
Observation Wells

Well Name	X (ft)	Y (ft)
□ E-OW-1S	4.33	0

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 3.729 cm^2/sec S = 0.1479



72 HOUR PUMPING TEST AND RECOVERY ANALYSIS

Data Set: C:\FAA\Area E\Pumping Test Data\Monday 930\Aqtesolv\E-OW-1S\Neuman E-OW-1S.aqt
Date: 05/06/10 Time: 09:38:02

PROJECT INFORMATION

Company: TRC
Client: FAA
Project: 162662
Location: Area E
Test Well: E-MW-2S
Test Date: April 16, 2010

AQUIFER DATA

Saturated Thickness: 35. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
E-MW-2S Pumping Well	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ E-OW-1S	4.33	0

SOLUTION

Aquifer Model: Unconfined

Solution Method: Neuman

T = 4.302 cm^2/sec

S = 0.03733

Sy = 0.3552

ß = 0.003061